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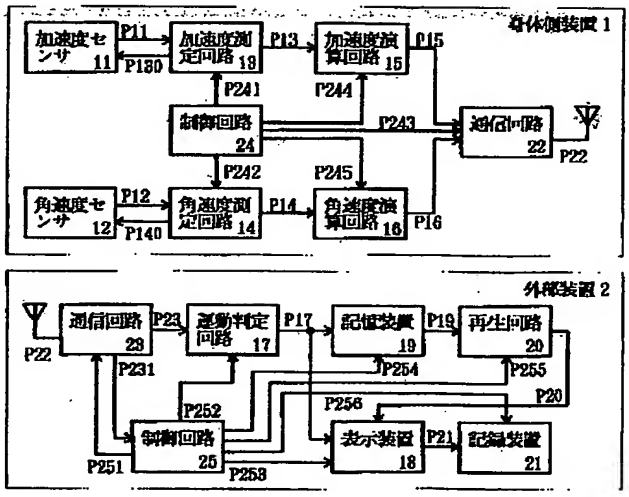
(54)【発明の名称】身体動作センシング装置

(57)【要約】
【課題】　歩行および脳疾患患者等のリハビリテーションの評価情報を含む使用者の身体の動作を検出し、それが所定の動作であることを判別してその情報を表示し、評価のため本人あるいは観察者に提供することができる身体動作センシング装置を提供すること。
【解決手段】　１つの方向（例えば鉛直）の加速度と１つの面内（例えば前後方向と鉛直方向を含む）の回転角速度を検出できる運動センサを含む身体側装置（例えば腕時計型）によって測定した加速度出力と角速度出力とにそれぞれ所定の演算（例えば検出波形の分散を求める）を施した結果の組み合わせによって身体運動の種類および強度を判定しそれらを表示する機能を有する身体動作センシング装置。



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【特許請求の範囲】

【請求項１】　１つの方向の加速度と１つの軸の回りの回転角速度を測定できる運動センサと、該運動センサによって前記１つの方向の加速度と１つの軸の回りの回転角速度とを所定の期間測定する測定回路手段とを含み、身体の所定の部位に装着される身体側装置と、該測定回路手段の加速度出力と角速度出力とにそれぞれ所定の演算を施す演算回路手段と、前記所定の演算が施された加速度出力と角速度出力との組み合わせによって前記所定の期間における身体運動の種類および強度を判定する判定回路手段と、前記判定された身体運動の種類および強度あるいはその評価結果を表示する表示手段とを有することを特徴とする身体動作センシング装置。

【請求項２】　前記運動センサと、前記測定回路手段と、前記演算回路手段と、前記判定回路手段と、前記表示手段が、全て身体の所定の部位に装着される身体側装置に内蔵されていることを特徴とする請求項１の身体動作センシング装置。

【請求項３】　前記運動センサと、前記測定回路手段と、前記演算回路手段と、前記判定回路手段と、前記表示手段のうち、少なくとも前記運動センサと前記測定回路手段とが身体の所定の部位に装着される身体側装置に内蔵されており、その他の手段が前記身体に装着されない外部装置に内蔵されており、かつ前記身体側装置は中間データの送信手段を備え、前記外部装置は前記中間データの受信手段を備えていることを特徴とする請求項１の身体動作センシング装置。

【請求項４】　前記運動センサの検出する１つの方向の加速度は身体のほぼ上下方向の加速度であり、また前記運動センサの検出する１つの方向の角速度は身体のほぼ鉛直方向および前後方向を含む平面内における回転運動に対する角速度であることを特徴とする請求項１ないし３のいずれかの身体動作センシング装置。

【請求項５】　前記身体側装置は腕に装着される機器であり、その内部で前記運動センサの角速度センサ部は厚みの薄い箱型の容器に収納されていて前記身体側装置の最も広い面にほぼ平行に配置されており、前記角速度センサ部の検出回転方向は前記箱型の容器の最も広い表面にほぼ平行な方向であることを特徴とする請求項１ないし４のいずれかの身体動作センシング装置。

【請求項６】　前記身体側装置は主な表面に表示装置を有し、前記運動センサの箱型の容器には一体化された構造の加速度センサ部と角速度センサ部とが収納されており、また前記運動センサの容器は前記表示装置にほぼ平行に前記身体側装置内に配置されており、前記運動センサの加速度検出方向は前記箱型の容器の最も広い表面にほぼ平行な方向であることを特徴とする請求項５の身体動作センシング装置。

【請求項７】　前記所定の演算は、前記加速度出力と前記角速度出力の少なくとも一方の分散を求めることであ

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ることを特徴とする請求項１ないし６のいずれかの身体動作センシング装置。

【請求項８】　前記所定の演算は、前記加速度出力と前記角速度出力の少なくとも一方の分散を求め、更にその対数をとることであることを特徴とする請求項７の身体動作センシング装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、身体が行った運動を検出し、その情報を観測者に提供することができる身体動作センシング装置に関する。

【０００２】

【従来の技術】使用者の身体に取付け、身体の運動をセンサで検出してそのデータで使用者の運動状況を判断し、健康管理等の目的に利用する発明の提案は数多い。例えば、

（１）特開平１０－２９５６５１号に開示された技術において、利用者が身につけた（腰などに）加速度計を持つ携帯端末は、入力しておいた個人データと自動計測した運動量を外部のセンタコンピュータに電話送信し分析して健康診断させ、その結果を受信し表示する。

【０００３】（２）特開２０００－４１９５３号に開示された技術においては、行動データ収集装置（利用者身体側）の体動センサが検出した体動を１次加工し、それを受信した行動データ出力装置（外部パソコン側）は個人情報を用いて２次加工したデータを出力する。生体情報収集機器側での個人情報入力や大量の２次加工情報の蓄積を不要とし、操作性やメモリ容量の削減を図る。

（３）特開２０００－４１９５２号においては、行動情報検出機器のメモリ容量を低減するため、センサと体動検出回路の出力より内部ＭＰＵを用いて歩数、歩行ペース、行動の種類、運動強度、消費カロリ等の生体情報を計算し、１分毎に計算結果を記憶、表示、あるいは外部に送信する。

【０００４】（４）その他、歩数計（万歩計（登録商標））や多機能型の腕時計等に加速度センサを内蔵させ、歩数や運動強度を測定して運動による消費カロリー等の健康管理情報を知らせるようにした製品や文献もあったようである。

（５）更に医療管理上の目的で、行動に障害を生じた患者の動作のモニタリング、あるいは緊急自動通報を行うため、加速度センサに加えて振動ジャイロスコープ等の回転角速度センサを追加して、特定の運動の検出を目的とする研究や実験がなされていることが関連学会における報告などに見られる。

（６）一方運動センサ技術を見ると、従来加速度と角速度は別個のセンサで測定されていた。殊に角速度センサではフリーフリーバーや２脚の音叉をコリオリ力を検知する振動体として利用した振動ジャイロスコープが実用されつつある。

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【０００５】
【発明が解決しようとする課題】上記従来例（１）、（２）、（３）における発明の各実施の形態を見るに、まだ十分に小型で装着による使用者（体が不自由な患者である場合が多い）の負担が少ない身体側機器が提案されているとは言えないと考えられる。従来例（４）では機器の小型化の点では進歩があるが、これらの従来例では得ようとしている情報が健常者の健康管理の範囲内に止まっており、例えば患者のリハビリテーションの評価等の医療目的にも直ちに用いうる技術ではない。

【０００６】上記従来例（５）の研究の目的は医療技術の改善であることでは本発明と共通する点もあるが、特定の疾患を対象としそれに関連する動作の検出を具体的な目的としており（例えば循環器系疾患と心機能に負担のかかる運動）、脳梗塞による麻痺患者の動作をも視野に入れようとする本発明に直接適用し難い部分が多い。また実際に患者に運動センサを装着する具体的な最適技術についての言及はあまりないようである。

【０００７】また従来例（６）に挙げた従来技術における角速度センサは、角速度が検出できる回転軸が２脚の音叉または棒状振動体の長手軸に平行、即ち検出可能な回転面は長手軸に垂直となっている。これは検出可能な回転面を身体に装着する装置の主な表面と平行とするとき必然的に身体側装置の厚さを増す。また加速度センサと角速度センサが別体であると身体側装置を大型にしてしまう。これらの事情により装着の負担感を軽減するため薄型・小型にすることが現状では困難である。なお他の形態のセンサが提案された例も多い。

【０００８】本発明の目的は、使用者の身体の動作を検出し、それが所定の動作であることを判別してその情報を表示し、本人あるいは観察者に提供することができる実用性の高い身体動作センシング装置を提供することである。また、少なくとも歩行の計測とリハビリテーションの評価を可能にした身体動作センシング装置を提供することである。

【０００９】
【課題を解決するための手段】上記目的を達成するため、本発明の身体動作センシング装置は次の特徴を備える。

（１）１つの方向の加速度と１つの軸の回りの回転角速度を測定できる運動センサと、該運動センサによって前記１つの方向の加速度と１つの軸の回りの回転角速度とを所定の期間測定する測定回路手段とを含み、身体の所定の部位に装着される身体側装置と、該測定回路手段の加速度出力と角速度出力とにそれぞれ所定の演算を施す演算回路手段と、前記所定の演算が施された加速度出力と角速度出力との組み合わせによって前記所定の期間における身体運動の種類および強度を判定する判定回路手段と、前記判定された身体運動の種類および強度あるいはその評価結果を表示する表示手段とを有すること。

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【００１０】本発明の身体動作センシング装置は更に以下の特徴の少なくとも一つを備えることがある。

（２）前記運動センサと、前記測定回路手段と、前記演算回路手段と、前記判定回路手段と、前記表示手段が、全て身体の所定の部位に装着される身体側装置に内蔵されていること。

【００１１】（３）前記運動センサと、前記測定回路手段と、前記演算回路手段と、前記判定回路手段と、前記表示手段のうち、少なくとも前記運動センサと前記測定回路手段とが身体の所定の部位に装着される身体側装置に内蔵されており、その他の手段が前記身体に装着されない外部装置に内蔵されており、かつ前記身体側装置は中間データの送信手段を備え、前記外部装置は前記中間データの受信手段を備えていること。

【００１２】（４）前記運動センサの検出する１つの方向の加速度は身体のほぼ上下方向の加速度であり、また前記運動センサの検出する１つの方向の角速度は身体のほぼ鉛直方向および前後方向を含む平面内における回転運動に対する角速度であること。

【００１３】（５）前記身体側装置は腕に装着される機器であり、その内部で前記運動センサの角速度センサ部は厚みの薄い箱型の容器に収納されていて前記身体側装置の最も広い面にほぼ平行に配置されており、前記角速度センサ部の検出回転方向は前記箱型の容器の最も広い表面にほぼ平行な方向であること。

【００１４】（６）前記身体側装置は主な表面に表示装置を有し、前記運動センサの箱型の容器には一体化された構造の加速度センサ部と角速度センサ部とが収納されており、また前記運動センサの容器は前記表示装置にほぼ平行に前記身体側装置内に配置されており、前記運動センサの加速度検出方向は前記箱型の容器の最も広い表面にほぼ平行な方向であること。

【００１５】（７）前記所定の演算は、前記加速度出力と前記角速度出力の少なくとも一方の分散を求めることであること。

【００１６】（８）前記所定の演算は、前記加速度出力と前記角速度出力の少なくとも一方の分散を求め、更にその対数をとることであること。

【００１７】
【発明の実施の形態】図１は本発明の身体動作センシング装置の第１の実施の形態のブロック図である。本装置は使用者が身体の所定の部位に取り付ける身体側装置１と、例えば医療センター的な場所に設置される外部装置２より成る。身体側装置１の内部構成は、その特定の方向への加速度を検知する加速度センサ１１、特定の面に平行な回転の角速度を検知する角速度センサ１２、それら機械的振動体であるセンサを各々励振し（駆動信号はＰ１３０およびＰ１４０）また加速度および角速度の検出信号Ｐ１１およびＰ１２を抽出し検波・増幅等の処理をしてそれぞれ検出値に比例する電圧を出力する加速度

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測定回路１３および角速度測定回路１４を含んでいる。

【００１８】所定の期間（使用者自身が決める、あるいは予め使用者と医療関係者が打合わせて決める、あるいは装置が自己の時計で決める等種々考えられる）内の加速度出力Ｐ１３と角速度出力Ｐ１４はそれぞれ加速度演算回路１５および角速度演算回路１６によって所定の演算が施される。所定の演算とは信号Ｐ１３、Ｐ１４の波形に加工を施して信号を変換することであり、例えば入力波形のピーク値を抽出する、整流・平滑化を行って平均化する、所定期間に現れる波形のピーク値の分散値を求める、所定期間の信号を細かくサンプリングしてその分散値を出す、また更にそれらの対数を求める、あるいはその他の数学的処理を行うことや、振動する波形の周期を求めること等を意味する。それらの出力である運動データは加速度演算出力Ｐ１５および角速度演算出力Ｐ１６である。この両出力は通信回路２２によって、例えば電波出力Ｐ２２として外部装置２に対して共に送信される。データの送受信は双方の通信回路２２、２３が連携し、互いの動作をチェックしながら双方向的に行われる。また制御回路２４は身体側装置１内の各回路に作用し、制御信号Ｐ２４１、Ｐ２４２、Ｐ２４３、Ｐ２４４、Ｐ２４５を発生し、各回路の動作タイミングや各回路間の連携動作を調整する役割を持つ。

【００１９】外部装置２の構成および動作は以下のようである。電波信号Ｐ２２に含まれる運動データを受信した通信回路２３はそれを復調し内部信号Ｐ２３に変換する。運動判定回路１７は内部信号Ｐ２３を受けて、それに含まれる加速度演算出力と角速度演算出力の２種類の情報とあらかじめ何種類かの運動について実験的に求めておいたそれぞれの数値範囲とを比較し、ある期間内に使用者が行った運動の種類とその強度を判定する。あるいは更に判定された運動に対する評価（例えばリハビリテーションの進度状況等）の情報も付加する。

【００２０】それらの情報を含む判定結果信号Ｐ１７は記憶装置１９に記憶されると共に表示装置１８（必要な回路を含む）に送られてその内容（運動の種類、強度、その評価）等があらかじめ登録されていた使用者の個人情報と共に表示され、記録装置２１にて記録され、医療担当者など観察者の診断を可能にする。また記憶された内容を含む記憶信号Ｐ１９は、再生回路２０によって必要に応じて再生信号Ｐ２０として随時再生され、表示装置１８により表示される。制御回路２６は外部装置２内の各回路に作用し、受信信号Ｐ２３１を受け、制御信号Ｐ２５１、Ｐ２５２、Ｐ２５３、Ｐ２５４、Ｐ２５５、Ｐ２５６を発生し、各回路の動作タイミングや各回路間の連携動作を調整する役割を持つ。

【００２１】図２は本発明の身体動作センシング装置の第２の実施の形態のブロック図である。本例では身体側装置１内に既に説明した必要な各回路および表示装置１８を有し（通信回路は不要となる）、運動の状況やその

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評価の情報が表示され、使用者（着用者）自身がそれを確認できる利点がある。もちろん記憶された情報を再生回路２０によって後刻再生させ、第三者等に確認させたり外部機器に記録させたりすることも可能である。制御回路２６は身体側装置１内の各回路に作用し、制御信号Ｐ２６１、Ｐ２６２、Ｐ２６３、Ｐ２６４、Ｐ２６５を発生し、各回路の動作タイミングや各回路間の連携動作を調整する。

【００２２】図３は本発明の実施の形態における身体側装置の一例を示し、（ａ）は部分平面図、（ｂ）はそのＡ－Ａ断面図である。本身体側装置３はほぼ腕時計型をしており、腕巻き用のバンド３６を備えて手首に装着できる。主要な部品として運動センサ３１、表示装置３２、通信回路モジュール３３、電源となる電池３４、操作スイッチ３５を示した。身体側装置３は装着が使用者の負担にならぬように薄型・小型でなくてはならない。表示装置３２は見易さを重視すると腕時計の表示面に相当する身体側装置３の最も広い表面に配置することになる。運動センサ３１も同じ面に、従って表示装置３２と平行に配置する。表示装置３２は液晶表示パネル等薄型のものが利用できるので、運動センサ３１も十分薄いパッケージに納められていなければならない。

【００２３】運動センサ３１を表示装置３２と平行に配置する理由は次の通りである。最適な運動検出方向は、後に述べるような実験結果から、加速度については身体の上下（鉛直）方向の直線運動即ち（ａ）図に示すＸ方向、回転角速度については身体の上下方向と前後方向の双方を含む平面内の回転（同図のΩ方向）、即ち身体の左右方向を向きかつ水平な回転軸（図示Ｚ軸に平行）回りの回転運動である。身体側装置３を腕時計のように、表示面が手首の甲側または掌側になるよう装着したとき（これが最も自然で望ましい）、上体を直立させ肘を自然に曲げ伸ばしするとき、その回転面は身体側装置３の表示面すなわち表示装置３２と平行になるので、その最も広い面に平行な回転検出面を持つ薄型の角速度センサがあれば、それを内部に含む運動センサ３１を表示装置３２と平行に配置することが好ましい。

【００２４】図４は本発明の実施の形態における運動センサの一例の内部構造を示す平面図である。この運動センサの構造は上記のような形状、配置、検出方向に関する要求を全て満たすものである。４０は薄い箱型で気密（好ましくは真空）の容器で、内部構造を示すため蓋（容器の天井部分）を取り除いてある。４１は容器の底部を貫通する多数のハーメチック端子ピンである。各ピンは運動センサ振動体５０上の電極膜群の個々と例えばワイヤボンディングの手法で接続されるが、電極膜やボンディングワイヤは図示を省略してある。運動センサ振動体５０は１枚の圧電性材料の平板から成形されており、加速度センサ部と角速度センサ部が一体化されている。運動センサ振動体５０は総基部５１の裏面の固定部

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Ａ５２（斜線部）と、小面積の固定部Ｂ６４（斜線部）の裏面とが容器４０側の台座（図示せず）上に接着され支持されている。

【００２５】角速度センサ部はいわゆる三脚音叉型の形状をした部分であり、各々平行な外脚Ａ５３、外脚Ｂ５５、中脚Ｃ５４、および音叉基部５６、支点５７より成る。外脚Ａ５３と外脚Ｂ５５とは通常の２脚音叉と同様にそれぞれが片持ち梁的で対称軸（図示せず）に関して対称な振動を行うように、角速度測定回路（例えば図１の１３）に含まれる励振回路（発振回路）によって一定振幅で励振させられている。中脚Ｃ５４は励振されないが、その撓みを検出するための表面電極を持っている。固定部と異なるハッチングを付して示した５８Ａ、５８Ｂ、５８Ｃはそれぞれ付加質量で、固有振動数を下げかつ互いに等しくするために脚先端部に施した金属の厚メッキ層等より成る（中脚Ｃ５４の固有振動数は両外脚の固有振動数と適宜に差をつけることがある）。

【００２６】今運動センサ５０が図示の方向、即ち紙面に垂直なＺ軸に平行な回転軸の回りに角速度Ωで回転すると、両外側の振動脚には角速度Ωに比例するコリオリ力が作用する。その方向は脚の長手方向であって、ある瞬間外脚Ａ５３に脚先端向きの力が作用すれば、外脚Ｂ５５には脚の基部に向かう力が作用する。力の方向は脚の振動と同期して正弦的に変化し周期的に反転する。２つの力は両外脚が平行に離れているため偶力を構成し、音叉基部５６を揺さぶり、支点５７の回りに微小な回転振動を惹起する。このコリオリ力によるモーメントに起因する音叉基部５６の振動を感知して中脚Ｃ５４はコリオリ力に比例した振幅で振動する。中脚Ｃ５４に設けた検出電極で抽出された振動電圧が角速度の検出信号（図１のＰ１１）である。

【００２７】運動センサ５０の加速度センサ部は１対の平行な振動するバネ部である棒Ａ６１、棒Ｂ６２、負荷質量６０（広い面積の素材板の一部の質量とその表面に施した厚メッキ材の質量とよりなる）、２本の支持バネ６３（負荷質量６０を支持しながら図示Ｚ方向の微小な変位を許すための部材）、固定部Ｂ（負荷質量６０が特にＸ方向に大きく変位しないように支持固定するための部分）より成る。各々両端固定である棒Ａ６１、棒Ｂ６２は運動センサ５０の対称軸に関して対称な弓形をなす振動姿態で発振回路（例えば図１の角速度測定回路１４に含まれる）によって励振させられる。

【００２８】その発振周波数は通常一定であるが、負荷質量６０に図示Ｘ方向の加速度が作用すると、その大きさに比例する力で負荷質量６０は棒Ａ６１、棒Ｂ６２をその長手方向に圧縮あるいは引張ることになり、その力の方向と大きさにより発振周波数が増減し変化する。そこで別途設けた基準周波数と上記発振周波数とを比較し、発振周波数の変化の方向と量を知ればＸ軸方向の加速度を求めることができる。基準周波数源を特に設け

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ず、代わりに角速度センサ用の振動体である外脚Ａ５３、Ｂ５５の発振周波数を利用し得る可能性もある。

【００２９】次に、本発明の最適な実施の形態を求めるために行った諸実験について、図５～図１０を用いて説明する。まず図５は身体動作センシングにおける振動応答の実験状況の説明図である。被験者である人体４を直立させ、片足を固定台５に乗せ、他の脚を鉛直方向に振動する加振機６の台上に乗せた。なお人体４を基準として図示のようにＸ，Ｙ，Ｚの座標軸を設定した。人体４に付した黒丸は、加速度センサを装着した部位を示す。そして先ずＸ方向（鉛直方向）の加振に対する各部位に装着したセンサの応答を求めた。加振は正弦波で４．９ｍ／ｓ＊ｓの一定加速度で５～１０００Ｈｚをスイープした。なおＸ方向の加速度は歩行等の普通の運動での消費カロリーを求めるために必須のデータでもある。

【００３０】図６は上記の実験条件で片方の足裏を加振したときの身体の各部位に装着した加速度センサのＺ方向の振動応答の実験結果を示すグラフで、横軸は加振周波数、縦軸は検出された加速度をそれぞれ対数目盛で示した。（ａ）は頭頂、（ｂ）は胸ポケット、（ｃ）は腰ベルト、（ｄ）は足首、（ｅ）は肘を延ばした手首、（ｆ）は肘を曲げて水平にした手首にそれぞれ装着した場合である。（ｃ）腰ベルト、（ｄ）足首、（ｅ）肘を伸ばした場合、（ｆ）肘を曲げた手首の各場合はセンサを体の加振側に取り着けた場合と体の中心軸（左右を分ける面）に関して対称な部位に取り付けた場合の両者を同じ図上に示して比較を容易にしてある。これらのデータを見るに、（ｅ）図で加振側と対称側の応答の差が全周波数範囲にわたってほとんどなく波形も最もなだらかである。また約２０Ｈｚ以上の足裏振動は伝達率が低く、歩行や走行の検出において履物や地面の固さの影響を受けにくく安定した検出が期待できる。これらの理由で、特別な身体部位の測定が目的でなければ、一般的には手首にセンサを装着するのが最も優れていることがわかる。

【００３１】次に脳梗塞による片麻痺患者の病状の程度を評価するために行われるテストの一例である「指ー鼻テスト」の運動検出を、手首に装着した加速度センサと角速度センサを用いて行ってみた。これはメトロノーム信号に合わせて指を繰り返し自分の鼻に持ってゆく動作を被検者にして貰う。図７は指ー鼻テストにおける右手および左手の運動の計測結果をそのまま検出波形で示すグラフで、横軸は時間（秒）、縦軸は検出値である。（ａ）、（ｂ）は健常者Ａ、（ｃ）、（ｄ）は健常者Ｂ、（ｅ）、（ｆ）は左上肢まひ患者の場合を示す。これらの図を見るに、二人の健常者ではいずれの側の手の動作も加速度、角速度とも滑らかで一定のリズムが認められるが、片側麻痺患者では動作のテンポが遅く、波形も乱れており、特に麻痺側の上肢の場合それが顕著であるから、症状の重篤さや過去のデータと比較しての改善

程度などが容易に判断でき、手首型の身体側装置が極めて有効であることがわかる。

【００３２】次に、手首に正しく装着した運動センサによって、数種類の歩行を各方向の加速度と角速度の測定結果を用いて識別する実験を行った。座標軸は図５に示した通りであり、Ｘ軸は直立した身体の上下軸、Ｙ軸は前後軸、Ｚ軸は水平な左右軸である。被験者は２０～４０代の男女１４名、運動の種類は普通歩行、早歩き、ジョギング、走行、腕拘束歩き（腕組み、ポケット入れ、鞄持ち）の５種であり、２０歩あるいは５０歩を一まとめとしてデータ採取を行った。検出波形はそのままではなく演算処理し加工してある。１つは振動のピーク（歩行に応じて測定回路から出力される振動的な電圧波形の各ピーク値）を検出した場合、他は波形を多点サンプリング（２０～５０歩の歩行中の波形電圧を５０Ｈｚでサンプリングする）して各点の値の分散（各データと平均値との差の２乗の平均）を計算した場合で、更にそれらの対数を取っている。結果は図８～図１０に分けて示してある。図８（ａ）はＸ軸とＹ軸の加速度波形の分散値同志、（ｂ）はＸ軸とＹ軸の加速度波形のピーク値同志を用いた図である。図９（ａ）はＸ軸加速度とＺ軸角速度、（ｂ）はＹ軸加速度とＺ軸角速度を採り、いずれも検出波形のピーク値を用いた図である。図１０（ａ）はＸ軸加速度とＺ軸角速度、（ｂ）はＹ軸加速度とＺ軸角速度の、いずれも分散値同志を用いた図である。

【００３３】各図を見るに、まずピーク値同志を組み合わせた図８（ｂ）および図９（ａ）、（ｂ）では各種の運動を示す測定点に互いに固まり、しかもかなり入り組んでいるものがあるため、運動の識別が確実に行われない恐れがある。それに対し、検出波形の分散値同志を組み合わせた例では、加速度同志である図８（ａ）では運動の分離性が悪いが、加速度と角速度を組み合わせた図１０の両図は比較的分離性が良い。中でも上下方向加速度Ｇｘと上下ー前後面内回転角速度Ωｚを用いた（ａ）図の方がやや識別性が良いと考えられる。

【００３４】以上の結果から、身体側装置内の運動の感受性方向として上下方向加速度Ｇｘと上下ー前後面内回転角速度Ωｚを用いるのが一般的な場合に運動識別上最適であり、これは図７のようなリハビリテーションの判定にも適しており、また例えば図４のような検出方向を持つ薄型の運動センサを用いて図３のような装着性と使用感の良い身体側装置によって実現できることを示している。

【００３５】本発明の実施の形態は、以上述べたいくつかの形態にとらわれないことはもちろんである。例えば、加速度や角速度の感受性の方向は、装置の使用目的によって異なる方位を選んでもよい。身体側装置と外部装置との間で送受信されるデータは必要な運動情報が伝達される限りどのようなものであってもよい。また身体側装置は時計や携帯電話等の機能を備えていてもよい（時計機能はタイミングの制御にも用いうる）。また身体側装置の装着位置も必ずしも手首に限らず例えば腕上任意の位置とすることができる。また運動計測結果は常に図８以下のように加工して表示するとは限らず、図７の各図のように加速度あるいは角速度の検出波形をそのまま表示してもよい。また測定値の演算処理も実験で示した以外に例えば絶対値の平均を求めるなど種々の場合があり得る。また他の方向の加速度あるいは角速度をも計測して補助データとし、診断や運動評価の精度を上げることも考えられる。

【００３６】また本装置の用途としては運動データの採取と評価に限られず、例えばコミュニケーションツールとしての利用がある。使用者が遠隔の医療担当者に対し「すぐに来て欲しい」等の何種類かの要求や意志の伝達を、予め取り決めておいた身体動作を合図として行い外部装置側で運動検出波形を分析してその合図動作即ち意図を知ることができる。

【００３７】

【発明の効果】本発明の身体動作センシング装置は、１方向の加速度と１方向の回転角速度を検出し、それらに所定の演算を加えて運動を判定しあるいは評価するので、

（１）最少限のセンサと測定回路により、簡素な構成でかつ身体側装置が小型化され、その電源にも余裕を持たせることができるし、取扱い易いコミュニケーションツールともなる基本的な効果を有する。

【００３８】請求項１の構成に請求項２～７の構成要件を加えることにより、それぞれ更に次の効果を加えることができる。

（２）動作判定結果や評価結果が身体側装置にて直読できるので使用者が健康の自己管理を容易に行える効果がある。

【００３９】（３）身体側装置からのデータ送信により、動作判定結果や評価結果が外部装置側に表示されるので、医療機関側で複数の使用者（患者）の状態を観察し管理することができる。また使用者からのメッセージを受け、対応した処置を行うことができる効果がある。

【００４０】（４）身体側装置の直線運動と回転運動の身体に関する検出方向を特定することにより、少ない検出要素数で目的に応じた必要かつ十分な情報が得られる効果がある。また特に重要な歩行や走行運動と上肢の運動の双方を検出できるので、例えば消費エネルギの推定やリハビリテーションの評価が可能となる。

【００４１】（５）身体側装置の最も広い面と薄型の運動センサの最も広い面と検出回転面をほぼ平行としたので、薄型で装着負担感が少ない身体側装置が実現できた効果がある。

【００４２】（６）更に加速度センサを角速度センサと一体化しかつ表示部と重ねたので、更に小型化され表示も見やすい身体側装置が実現できた効果がある。

【００４３】（７）加速度出力あるいは角速度出力の分散を求めることにより、運動の種類の判別がより明確になる効果がある。

【００４４】（８）更に運動計測値の対数をとることにより、運動の種類の判別が更に明確になる効果がある。

【図面の簡単な説明】

【図１】本発明の第１の実施の形態のブロック図である。

【図２】本発明の第２の実施の形態のブロック図である。

【図３】本発明の実施の形態における身体側装置の一例を示し、（ａ）は部分平面図、（ｂ）はそのＡ－Ａ断面図である。

【図４】本発明の実施の形態における運動センサの内部構造を示す平面図である。

【図５】身体動作センシングにおける振動応答の実験状況の説明図である。

【図６】身体の各部位の振動応答の実験結果を示すグラフで、（ａ）は頭頂、（ｂ）は胸ポケット、（ｃ）は腰ベルト、（ｄ）は脚首、（ｅ）は肘を延ばした手首、（ｆ）は肘を曲げて水平にした手首の場合である。

【図７】指－鼻テストにおける右手および左手の運動の計測結果を示すグラフで、（ａ）、（ｂ）は健常者Ａ、（ｃ）、（ｄ）は健常者Ｂ、（ｅ）、（ｆ）は左上肢まひ患者の場合を示す。

【図８】各種の身体運動を行って手首の各方向の運動データを演算処理して組合わせた実験結果を示すグラフで、（ａ）はＸ軸とＹ軸の加速度波形の分散値同志、（ｂ）はＸ軸とＹ軸の加速度波形のピーク値同志を用いた図である。

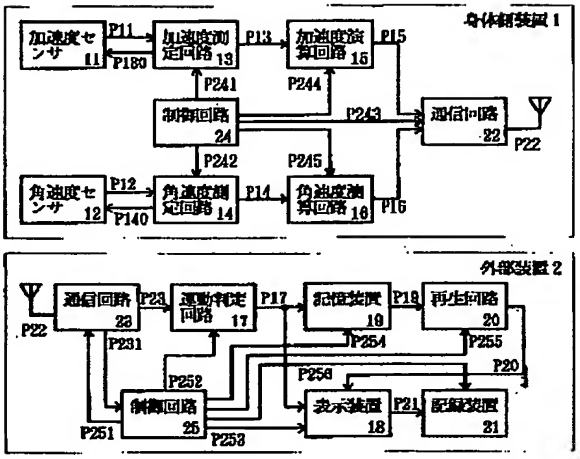
【図９】各種の身体運動を行って手首の各方向の運動データを演算処理して組合わせた実験結果を示すグラフで、（ａ）はＸ軸加速度とＺ軸角速度、（ｂ）はＹ軸加速度とＺ軸角速度を採り、いずれも検出波形のピーク値を用いた図である。

【図１０】各種の身体運動を行って手首の各方向の運動データを演算処理して組合わせた実験結果を示すグラフで、（ａ）はＸ軸加速度とＺ軸角速度、（ｂ）はＹ軸加速度とＺ軸角速度の、いずれも分散値同志を用いた図である。

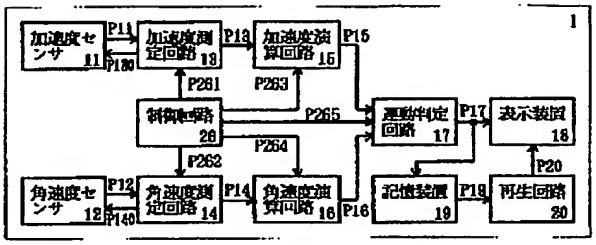
【符号の説明】

１、３　身体側装置
２　外部装置
４　人体
５　固定台
６　加振機
１１　加速度センサ
１２　角速度センサ
１３　加速度測定回路
１４　角速度測定回路
１５　加速度演算回路
１６　角速度演算回路
１７　運動判定回路
１８　表示装置
１９　記憶装置
２０　再生回路
２１　記録装置
２２、２３　通信回路
２４、２５、２６　制御回路
３１　運動センサ
３２　表示装置
３３　通信モジュール
３４　電池
３５　操作スイッチ
３６　腕巻きバンド
４０　センサ容器
４１　ハーメチック端子ピン
５０　運動センサ振動体
５１　総基部
５２　固定部Ａ
５３　外脚Ａ
５４　中脚Ｂ
５５　外脚Ｃ
５６　音叉基部
５７　支点
５８Ａ、５８Ｂ、５８Ｃ　脚付加質量
６０　負荷質量
６１　棒Ａ
６２　棒Ｂ
６３　支持バネ
６４　固定部Ｂ
Ｇ　加速度
Ｚ　座標軸
Ω　角速度

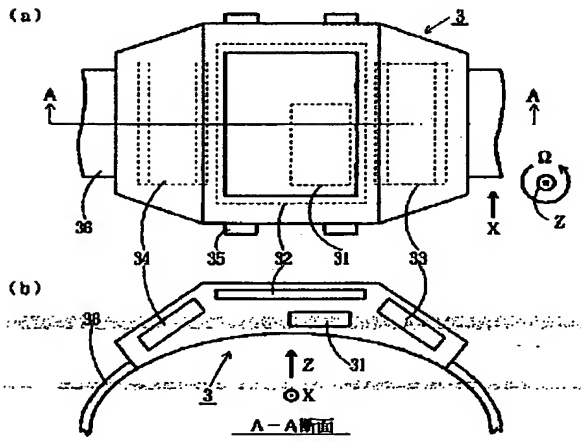
【図　1】


身体制装置 1
加速度センサ 11
加速度測定回路 13
加速度演算回路 15
制御回路 24
通信回路 22
角速度センサ 12
角速度測定回路 14
角速度演算回路 16
外部装置 2
通信回路 23
運動判定回路 17
記憶装置 19
再生回路 20
制御回路 25
表示装置 18
記録装置 21

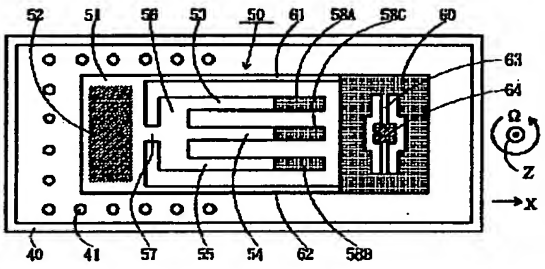
【図　2】


1
加速度センサ 11
加速度測定回路 13
加速度演算回路 15
制御回路 26
運動判定回路 17
表示装置 18
角速度センサ 12
角速度測定回路 14
角速度演算回路 16
記憶装置 19
再生回路 20

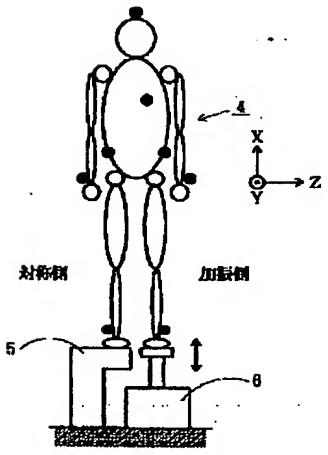
【図　3】


(a)
(b)
A－A断面

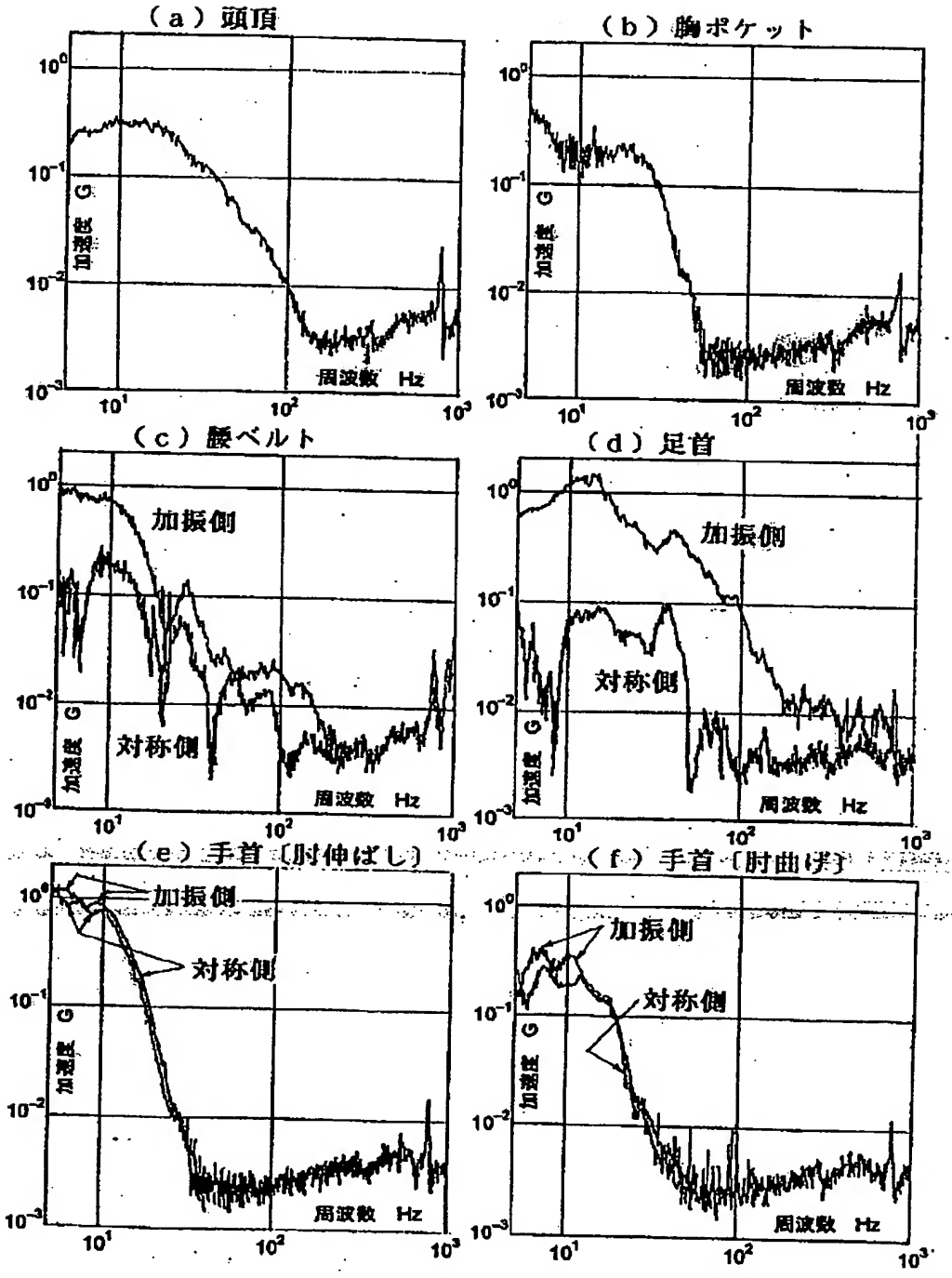
【図　4】



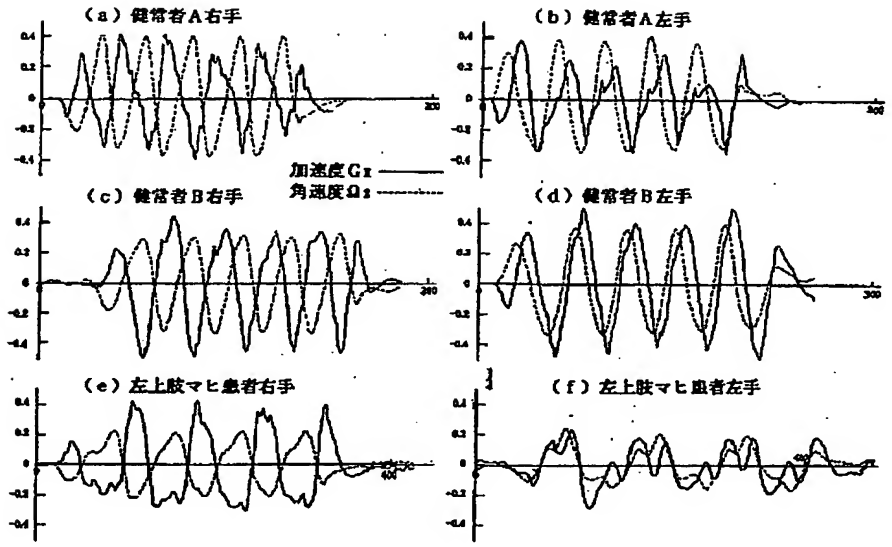
【図　5】


対称側
加振側

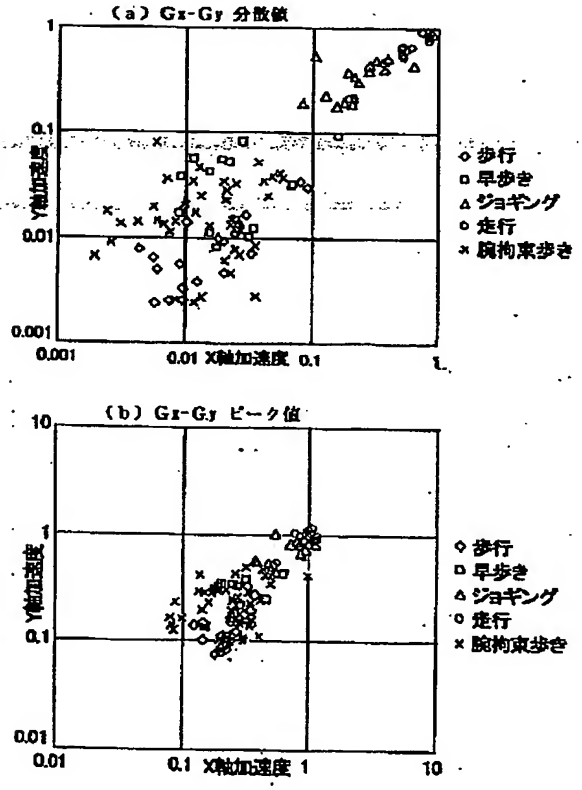
【図 6】



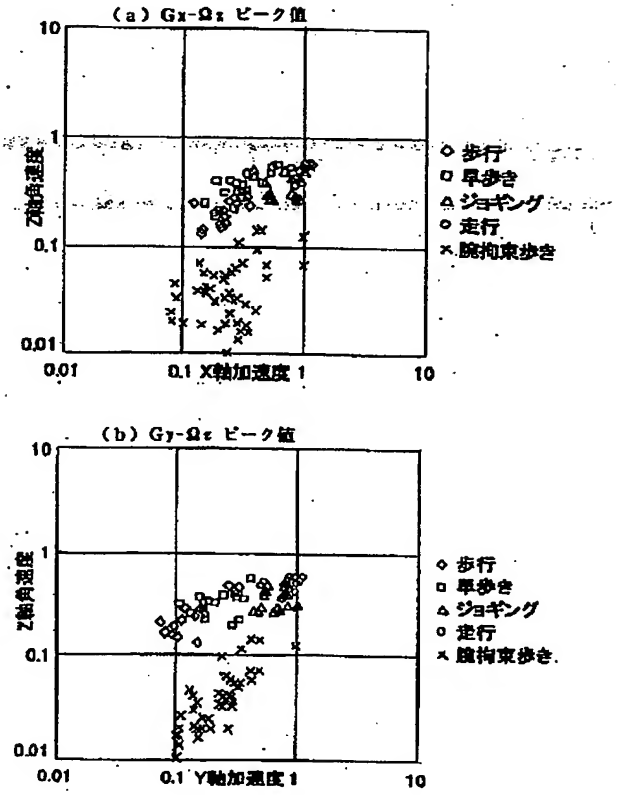
【図　7】


(a) 健常者A右手
(b) 健常者A左手
加速度Gx
角速度Ωz
(c) 健常者B右手
(d) 健常者B左手
(e) 左上肢マヒ患者右手
(f) 左上肢マヒ患者左手

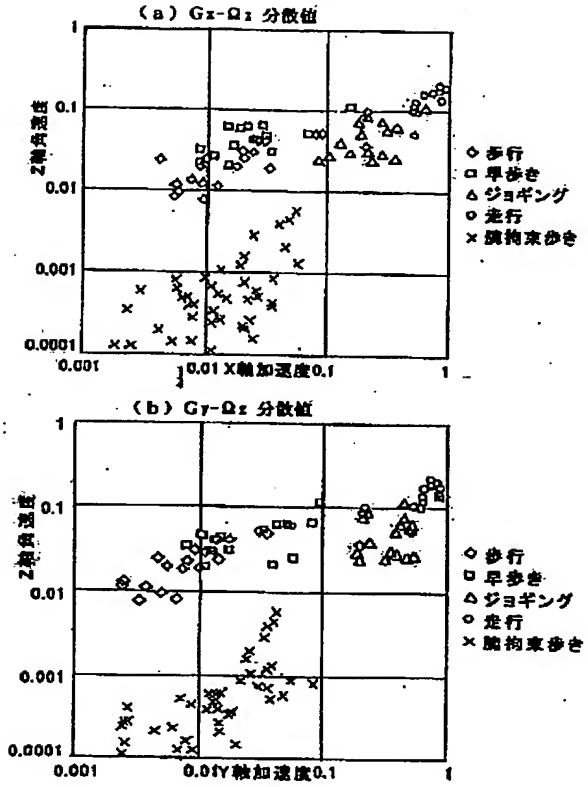
【図　8】


(a) Gx-Gy 分散値
Y軸加速度
X軸加速度
◇ 歩行
□ 早歩き
△ ジョギング
○ 走行
× 腕拘束歩き
(b) Gx-Gy ピーク値
Y軸加速度
X軸加速度
◇ 歩行
□ 早歩き
△ ジョギング
○ 走行
× 腕拘束歩き

【図　9】


(a) Gx-Ωz ピーク値
Z軸角速度
X軸加速度
◇ 歩行
□ 早歩き
△ ジョギング
○ 走行
× 腕拘束歩き
(b) Gy-Ωz ピーク値
Z軸角速度
Y軸加速度
◇ 歩行
□ 早歩き
△ ジョギング
○ 走行
× 腕拘束歩き

【図１０】



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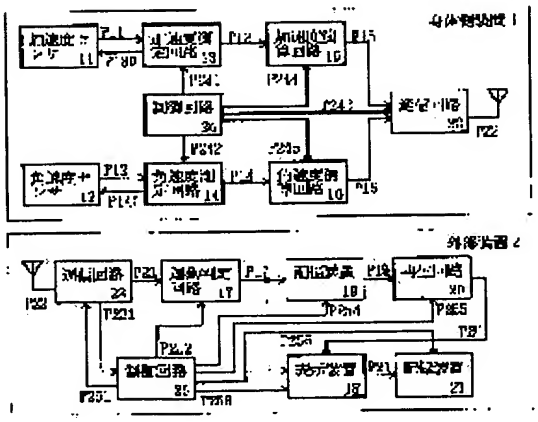
(54) BODY ACTION SENSING INSTRUMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a body action sensing instrument capable of sensing user's body actions including evaluation information of a walk and rehabilitation of a cerebropathic patient, judging whether or not the actions are prescribed actions to display the information, and providing the person himself/herself or a observing person with the information for evaluation.
SOLUTION: The body action sensing instrument has a function of judging types and strength of body actions based on a combination of the results of prescribed computation (e.g. dispersion of sensed waveform) on an acceleration output and rotational angular speed which are measured by a device at body side (e.g. wrist watch type) including an action sensor capable of sensing an acceleration in one direction (e.g. vertical direction) and a rotational angular speed in one surface (e.g. including forward/backward direction and vertical direction), and a function of displaying the results.



LEGAL STATUS

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[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

Laid-open Patent Application No. JP 2002-078697,A

CLAIMS

[Claim(s)]
[Claim 1] The movement sensor which can measure the acceleration of one direction, and the surrounding angular rate of rotation of one shaft, The body side equipment with which the predetermined part of the body is equipped including a measuring circuit means by which predetermined carries out period measurement of the acceleration of said one direction, and the surrounding angular rate of rotation of one shaft, by this movement sensor, An arithmetic circuit means to perform a predetermined operation to the acceleration output and angular-velocity output of this measuring circuit means, respectively, A judgment circuit means to judge the class and reinforcement of body movement in said predetermined period with the combination of the acceleration output and angular-velocity output to which said predetermined operation was performed, Body actuation sensing equipment characterized by having said display means to display the class and the reinforcement, or its evaluation result of judged body movement.
[Claim 2] Body actuation sensing equipment of claim 1 characterized by building all of said movement sensor, said measuring circuit means, said arithmetic circuit means, said judgment circuit means, and said display means in the body side equipment with which the predetermined part of the body is equipped.
[Claim 3] Said movement sensor, said measuring circuit means, said arithmetic circuit means, and said judgment circuit means, It is built in the body side equipment with which the predetermined part of the body is equipped with said movement sensor and said measuring circuit means at least among said display means. It is body actuation sensing equipment of claim 1 characterized by building other means in the external device with which said body is not equipped, and having equipped said body side equipment with the transmitting means of middle data, and equipping said external device with the receiving means of said middle data.
[Claim 4] For the angular velocity of one direction which the body is the acceleration of the vertical direction mostly, and said movement sensor detects, the acceleration of one direction which said movement sensor detects is claim 1 characterized by being the angular velocity to rotation within the flat surface of the body which contains the direction of a vertical, and a cross direction mostly thru/or one body actuation sensing equipment of 3.
[Claim 5] Said body side equipment is claim 1 which is the device with which an arm is equipped, the angular-velocity sensor section of said movement sensor is contained by the container of a core box with thin thickness in the interior, is arranged almost in parallel with the largest field of said body side equipment, and is characterized by for the detection hand of cut of said angular-velocity sensor section to be a direction almost parallel to the largest front face of the container of said core box thru/or one body actuation sensing equipment of 4.
[Claim 6] Said body side equipment is body actuation sensing equipment of claim 5 which it has a display on the main front faces, and the acceleration-sensor section and the angular-velocity sensor section of structure which were unified are contained by the container of the core box of said movement sensor, and the container of said movement sensor is arranged in said body side equipment almost in parallel with said display, and is characterized by for the acceleration

detection direction of said movement sensor to be a direction almost parallel to the largest front face of the container of said core box.
[Claim 7] Said predetermined operation is claim 1 characterized by being asking for one [at least] distribution of said acceleration output and said angular-velocity output thru/or one body actuation sensing equipment of 6.
[Claim 8] Said predetermined operation is body actuation sensing equipment of claim 7 characterized by being asking for one [at least] distribution of said acceleration output and said angular-velocity output, and taking the logarithm further.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention detects movement which the body performed and relates to the body actuation sensing equipment which can provide a watcher with the information.
[0002]
[Description of the Prior Art] Many [the proposal of invention which attaches in a user's body, detects movement of the body by the sensor, judges a user's movement situation by the data, and is used for the purposes, such as health care,] For example, telephone transmission is carried out, the momentum which carried out automatic meter reading to the inputted personal data is analyzed to an external center computer, and the personal digital assistant which has the accelerometer which the user put on in the technique indicated by (1) JP,10-295651,A (waist etc.) carries out a medical checkup to it, and receives and displays the result.
[0003] (2) In the technique indicated by JP,2000-41953,A, process the primary body motion which the body motion sensor of an action data collector (user body side) detected, and the action data output equipment (external personal computer side) which received it outputs the data which carried out secondary elaboration using individual humanity news. Individual humanity news input by the side of a living body information gathering device and are recording of a lot of secondary elaboration information are made unnecessary, and reduction of operability or memory space is aimed at.
(3) In JP,2000-41952,A, in order to reduce the memory space of an action information detection device, from the output of a sensor and a body motion detector, calculate biological information, such as the number of steps, a walk pace, a class of action, exercise intensity, and a consumption calorie, using Interior MPU, and transmit a count result to storage, a display, or the exterior for every minute.
[0004] (4) It seems that in addition, an acceleration sensor is made to build in a pedometer (pedmeter (trademark)), the wrist watch of a multifunctional mold, etc., and there were also the product and reference which measure the number of steps and exercise intensity and told health management information, such as a consumption calorie by movement.
(5) In order to perform the monitoring of actuation of the patient who produced the failure in action, or an urgent automatic announcement for the purpose on medical supervision furthermore, in addition to an acceleration sensor, angular-rate-of-rotation sensors, such as an oscillating gyroscope, are added, and a report [in / in research and an experiment of specification aiming at detection of movement being made / a related society] etc. sees.
(6) On the other hand, when the movement sensor technique was seen, acceleration and angular velocity were conventionally measured by the separate sensor. By the angular-velocity sensor, the oscillating gyroscope which used the free free bar and the tuning fork of 2 pieces as an oscillating object which detects Coriolis force is being used especially.
[0005]
[Problem(s) to be Solved by the Invention] It is still small fully for seeing the gestalt of each implementation of invention in the above-mentioned conventional example (1), (2), and (3), and the burden of the user (the body is an inconvenient patient in many cases) by wearing is considered that it cannot say that few body side devices are proposed. Although there is an advance in respect of the miniaturization of a device in the conventional example (4), it is not the

technique which the information which it is going to acquire in these conventional examples has stopped within the limits of a healthy person's health care, for example, can be immediately used also for the medical purposes, such as evaluation of a patient's rehabilitation.

[0006] Although the purpose of research of the above-mentioned conventional example (5) also have the point which be common in this invention in it be the improvement of the iatrotechnique, detection of the actuation relevant to it be target the specific disease as the concrete purpose (for example, movement which a burden require for a circulatory system disease and cardiac performance), and there be many parts which cannot apply actuation of paralytic [by cerebral infarction] to this invention which it be going to put into a visual field easily directly, either. It seems that moreover, there is no reference about the concrete optimal technique which actually equips a patient with a movement sensor not much.

[0007] Moreover, surface of revolution, the revolving shaft with which the angular-velocity sensor in the conventional technique mentioned as the conventional example (6) can detect angular velocity, i.e., detect, on the longitudinal shaft of the tuning fork of 2 pieces or a cylindrical oscillating object, is perpendicular to a longitudinal shaft. This increases the thickness of body side equipment inevitably, when parallel to the main front faces of the equipment which equips the body with detectable surface of revolution. Moreover, body side equipment will be carried out to an acceleration sensor and an angular-velocity sensor being another objects on a large scale. In order to mitigate the feeling of a burden of wearing according to these situations, in the present condition, it is difficult a thin shape and to make it small. In addition, there are also many examples as which the sensor of other gestalten was proposed.

[0008] The purpose of this invention is offering the high body actuation sensing equipment of the practicality with which detects actuation of a user's body, can distinguish it being predetermined actuation, and can display the information, and he or an observer can be provided. Moreover, it is offering the body actuation sensing equipment which enabled measurement of a walk, and evaluation of rehabilitation at least.

[0009]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the body actuation sensing equipment of this invention is equipped with the following description.

(1) The movement sensor which can measure the acceleration of one direction, and the surrounding angular rate of rotation of one shaft, The body side equipment with which the predetermined part of the body is equipped including a measuring circuit means by which predetermined carries out period measurement of the acceleration of said one direction, and the surrounding angular rate of rotation of one shaft, by this movement sensor, An arithmetic circuit means to perform a predetermined operation to the acceleration output and angular-velocity output of this measuring circuit means, respectively, Have a judgment circuit means to judge the class and reinforcement of body movement in said predetermined period with the combination of the acceleration output and angular-velocity output to which said predetermined operation was performed, and said display means to display the class and the reinforcement, or its evaluation result of judged body movement.

[0010] The body actuation sensing equipment of this invention may be further equipped with at least one of the following descriptions.

(2) Be built in the body side equipment with which the predetermined part of the body is equipped with all of said movement sensor, said measuring circuit means, said arithmetic circuit means, said judgment circuit means, and said display means.

[0011] (3) Said movement sensor, said measuring circuit means, and said arithmetic circuit means, It is built in the body side equipment with which the predetermined part of the body is equipped with said movement sensor and said measuring circuit means at least among said judgment circuit means and said display means. Other means are built in the external device with which said body is not equipped, and said body side equipment should have been equipped with the transmitting means of middle data, and said external device should be equipped with the receiving means of said middle data.

[0012] (4) The angular velocity of one direction where the body is the acceleration of the vertical direction mostly, and said movement sensor detects the acceleration of one direction which said

movement sensor detects should be the angular velocity to rotation within the flat surface of the body which contains the direction of a vertical, and a cross direction mostly.
[0013] (5) Said body side equipment is a device with which an arm is equipped, in the interior, the angular-velocity sensor section of said movement sensor is contained by the container of a core box with thin thickness, and is arranged almost in parallel with the largest field of said body side equipment, and the detection hand of cut of said angular-velocity sensor section should be a direction almost parallel to the largest front face of the container of said core box.
[0014] (6) Said body side equipment has a display on the main front faces, and the acceleration-sensor section and the angular-velocity sensor section of structure which were unified are contained by the container of the core box of said movement sensor, and the container of said movement sensor is arranged in said body side equipment almost in parallel with said display, and the acceleration detection direction of said movement sensor should be a direction almost parallel to the largest front face of the container of said core box.
[0015] (7) Said predetermined operation should be asking for one [at least] distribution of said acceleration output and said angular-velocity output.
[0016] (8) Said predetermined operation should be asking for one [at least] distribution of said acceleration output and said angular-velocity output, and taking the logarithm further.
[0017]
[Embodiment of the Invention] Drawing 1 is the block diagram of the gestalt of operation of the 1st of the body actuation sensing equipment of this invention. This equipment consists of the body side equipment 1 which a user attaches in the predetermined part of the body, and the external device 2 installed in a medical center-location. The internal configuration of body side equipment 1 The acceleration to the specific direction The angular velocity of rotation parallel to the acceleration sensor 11 to detect and a specific field Excite respectively the angular-velocity sensor 12 to detect and the sensor which is these mechanical oscillation object, extract the detecting signals P11 and P12 of acceleration and angular velocity again (a driving signal is P130 and P140), and detection, magnification, etc. are processed. The acceleration measuring circuit 13 and the angular-velocity measuring circuit 14 which output the electrical potential difference which is proportional to a detection value, respectively are included.
[0018] As for the acceleration output P13 and the angular-velocity output P14 within a predetermined period (or the user itself decides, beforehand, a user and a medical staff arrange, and it decides, or it is considered variously that equipment determines by the self clock etc.), a predetermined operation is performed by the acceleration arithmetic circuit 15 and the angular-velocity arithmetic circuit 16, respectively. A predetermined operation is processing it into the wave of signals P13 and P14, and changing a signal. For example, equalize by performing rectification and smoothing which extracts the peak value of an input wave. It means searching for those logarithms or performing other mathematical processings, furthermore it samples finely the signal of the predetermined period which calculates the variance of wave-like peak value which appears at a predetermined period and takes out the variance, asking for the vibrating wave-like period, etc. The movement data which are those outputs are the acceleration operation output P15 and the angular-velocity operation output P16. Both this output is transmitted [as opposed to / as an electric-wave output P22 / an external device 2 / both] by the communication circuit 22. Both communication circuits 22 and 23 cooperate, and transmission and reception of data are performed in both directions, checking mutual actuation. Moreover, a control circuit 24 acts on each circuit in body side equipment 1, generates control signals P241, P242, P243, P244, and P245, and has the role which adjusts the cooperation actuation between the timing of each circuit of operation, or each circuit.
[0019] The configuration and actuation of an external device 2 are as follows. The communication circuit 23 which received the movement data contained in the electric-wave signal P22 restores to it, and changes it into the internal signal P23. In response to the internal signal P23, beforehand, the movement judging circuit 17 compares two kinds of information included in it, an acceleration operation output and an angular-velocity operation output, with each numerical range for which it asked experimentally about that movement, and judges how many kinds of the classes and reinforcement of movement which the user performed within a

certain period. Or the information on evaluations (for example, progress situation of rehabilitation etc.) over movement judged further is also added.

[0020] The judgment result signal P17 including those information is sent to a display 18 (a required circuit is included), it is displayed with the individual humanity news of the user by whom the contents (the class of movement, reinforcement, its evaluation) etc. were registered beforehand, is recorded with a recording device 21, and enables a diagnosis of observers, such as a medical person in charge, while storage 19 memorizes. Moreover, a regenerative circuit 20 is reproduced at any time as a regenerative signal P20 if needed, and the storage signal P19 including the memorized contents is displayed with a display 18. A control circuit 26 acts on each circuit in an external device 2, receives an input signal P231, generates control signals P251, P252, P253, P254, P255, and P256, and has the role which adjusts the cooperation actuation between the timing of each circuit of operation, or each circuit.

[0021] Drawing 2 is the block diagram of the gestalt of operation of the 2nd of the body actuation sensing equipment of this invention. In this example, in body side equipment 1, it has each required circuit and required display 18 which were already explained (a communication circuit becomes unnecessary), the situation of movement and the information on the evaluation are displayed, and there is an advantage to which the user (wearer) itself can check it. It is possible to make it reproduce later on, to make a third person etc. check or to also make information memorized, of course record on an external instrument by the regenerative circuit 20. A control circuit 26 acts on each circuit in body side equipment 1, generates control signals P261, P262, P263, P264, and P265, and adjusts the cooperation actuation between the timing of each circuit of operation, or each circuit.

[0022] Drawing 3 shows an example of the body side equipment in the gestalt of operation of this invention, (a) is a part plan and (b) is the A-A sectional view. This body side equipment 3 is carrying out the wrist watch mold mostly, is equipped with the band 36 for arm volumes, and can equip a wrist with it. The movement sensor 31, the indicating equipment 32, the communication circuit module 33, the cell 34 used as a power source, and the actuation switch 35 were shown as main components. Body side equipment 3 must be a thin shape and small so that wearing may not become a user's burden. When a display 32 thinks conspicuousness as important, it will be arranged on the largest front face of the body side equipment 3 equivalent to the screen of a wrist watch. According to the same field, the movement sensor 31 is also arranged in parallel with a display 32. Since a display 32 can use thin things, such as a liquid crystal display panel, the movement sensor 31 must also be dedicated to the sufficiently thin package.

[0023] The reason for arranging the movement sensor 31 in parallel with a display 32 is as follows. The optimal movement detection direction turns to the rotation within the direction of X shown in the rectilinear motion, i.e., the (a) Fig., of the vertical (vertical) direction of the body about acceleration, and the flat surface which includes the both sides of the vertical direction of the body, and a cross direction about the angular rate of rotation (the direction of omega of this drawing), i.e., the longitudinal direction of the body, from an experimental result which is described later, and is rotation of the circumference of a level revolving shaft (parallel to the illustration Z-axis). body side equipment 3 -- a wrist watch -- like -- the screen -- the shell side of a wrist, or a palm, when supposing that it equipped so that it might become a side (this is the most natural and desirable), uprighting the upper part of the body, bending an elbow automatically, lengthening it and carrying out it Since the surface of revolution becomes parallel to the screen 32 of body side equipment 3, i.e., a display, if there is a thin angular-velocity sensor with a rotation detection side parallel to the largest field, it is desirable to arrange the movement sensor 31 which contains it inside in parallel with a display 32.

[0024] Drawing 4 is the top view showing the internal structure of an example of the movement sensor in the gestalt of operation of this invention. The structure of this movement sensor fills all of the above configurations, arrangement, and the demand about the detection direction. 40 is a container airtight (preferably vacuum) by the thin core box, and it has removed the lid (head-lining part of a container) in order to show a internal structure. 41 is the hermetic terminal pin of a large number which penetrate the pars basilaris ossis occipitalis of a container. Although each pin is connected by each of the electrode layer group on the movement sensor

oscillating object 50, and the technique of wirebonding, the electrode layer and the bonding wire have omitted illustration. The movement sensor oscillating object 50 is fabricated from the plate of the piezoelectric ingredient of one sheet, and the acceleration-sensor section and the angular-velocity sensor section are unified. the movement sensor oscillating object 50 -- the fixed part A52 (slash section) of the rear face of the total base 51, and a facet -- on the plinth by the side of a container 40 (not shown), the rear face of the fixed part B64 (slash section) of a product pastes up, and is supported.

[0025] The angular-velocity sensor section is the part which carried out the so-called tripod tuning fork type of configuration, and consists of the parallel outside foot A53, the outside foot B55, the inside foot C54 and the tuning fork base 56, and the supporting point 57 respectively. It is excited with the fixed amplitude by the excitation circuit (oscillator circuit) included in an angular-velocity measuring circuit (for example, 13 of drawing 1) so that the outside foot A53 and the outside foot B55 may be cantilever-like [each] like the usual 2-piece tuning fork and symmetrical vibration may be performed about a symmetry axis (not shown). Although the inside foot C54 is not excited, it has a surface electrode for detecting the bending. 58A, 58B, and 58C which attached and showed different hatching from a fixed part are an additional mass, respectively, and in order to lower a resonant frequency and to make it equal mutually, they consist of the thick deposit of the metal given to the foot point etc. (the resonant frequency of the inside foot C54 may give a difference as suitably as the resonant frequency of both ****).

[0026] If the movement sensor 50 rotates with angular velocity omega now around a revolving shaft parallel to the Z-axis perpendicular to the direction of illustration, i.e., space, the Coriolis force proportional to angular velocity omega will act on the oscillating foot of both outsides. The direction is a longitudinal direction of a foot, and if the force of the foot tip sense acts on the foot A53 outside a certain moment, the force of going to the base of a foot will act on the outside foot B55. The direction of the force changes in sine synchronizing with vibration of a foot, and is reversed periodically. Since it is separated from two force of both **** in parallel, a couple is constituted, the tuning fork base 56 is shaken, and a minute rotational vibration is caused in the surroundings of the supporting point 57. Sensing vibration of the tuning fork base 56 resulting from the moment by this Coriolis force, the inside foot C54 vibrates with the amplitude proportional to Coriolis force. The oscillating electrical potential difference extracted with the detection electrode prepared in the inside foot C54 is the detecting signal (R> 1 drawing 1 P11) of angular velocity.

[0027] The rod A61 whose acceleration-sensor sections of the movement sensor 50 are one pair of vibrating parallel spring sections, a rod B62, the load mass 60 (it consists of a part of mass of the material plate of a large area, and mass of the thick plating material given to the front face), It consists of two support springs 63 (member for allowing the minute variation rate of an illustration Z direction, supporting the load mass 60), and a fixed part B (part for carrying out support immobilization so that the load mass 60 may not displace greatly especially in the direction of X). The rod A61 which is both-ends immobilization respectively, and a rod B62 are excited by the oscillator circuit (for example, contained in the angular-velocity measuring circuit 14 of drawing 1) by the oscillating style which makes a symmetrical segment about the symmetry axis of the movement sensor 50.

[0028] Although the oscillation frequency is usually fixed, if the acceleration of the direction of illustration X acts on the load mass 60, the load mass 60 will compress or pull a rod A61 and a rod B62 to the longitudinal direction by the force proportional to the magnitude, and an oscillation frequency will fluctuate with the direction and magnitude of the force, and it will change. Then, the reference frequency and the above-mentioned oscillation frequency which were prepared separately are compared, and if the direction and amount of change of an oscillation frequency are got to know, it can ask for the acceleration of X shaft orientations. Especially the source of reference frequency is not prepared, but the oscillation frequency of the outside feet A53 and B55 which are the oscillating objects for angular-velocity sensors can be used for instead of.

[0029] Next, many experiments which search for the gestalt of the optimal operation of this invention and which went to accumulate are explained using drawing 5 - drawing 10 . Drawing 5

is the explanatory view of the experiment situation of the oscillating response in body actuation sensing first. The body 4 which is a test subject was uprighted, one leg was put on standing ways 5, and other feet were put on the base of the vibration exciter 6 which vibrates in the direction of a vertical. In addition, the axis of coordinates of X, Y, and Z was set up like illustration on the basis of the body 4. The black dot given to the body 4 shows the part equipped with an acceleration sensor. And the response of the sensor with which at least each part to the excitation of the direction of X (the direction of a vertical) was equipped first was calculated. Excitation carried out the sweep of the 5-1000Hz with the fixed acceleration of 4.9m[/s] *s by the sine wave. In addition, the acceleration of the direction of X is also indispensable data, in order to ask for the consumption calorie in ordinary movement of a walk etc.

[0030] Drawing 6 is the graph which shows the experimental result of an oscillating response of the Z direction of the acceleration sensor with which at least each part of the body when exciting sole of one of the two on the above-mentioned experiment conditions was equipped, and the axis of abscissa showed an excitation frequency and the acceleration with which the axis of ordinate was detected with logarithmic scale, respectively. (a) is the case where the top of the head and (b) equip with a chest pocket and (c) the wrist at which a waist belt and (d) extended the ankle and (e) extended the elbow, and the wrist which (f) bent the elbow and was leveled, respectively. (c) When a waist belt, the (d) ankle, and the (e) elbow are lengthened, each **** of a wrist which bent the (f) elbow shows both at the time of attaching a sensor in a symmetrical part about the medial axis (field which divides right and left) of the case where it took and sticks to a bodily excitation side, and the body on the same Fig., and has made the comparison easy. The difference of a wave of the response by the side of excitation and the symmetry is [that there is almost nothing] the most gently-sloping in the (e) Fig. over the perimeter wave number range for seeing these data. Moreover, sole vibration of about 20Hz or more has low transmissibility, and the detection which could not be easily influenced of the hardness of footwear or the ground and was stabilized in detection of a walk or transit can be expected. It turns out that it is most excellent in these reasons to equip a wrist with a sensor generally if measurement of a special body region is not the purpose.

[0031] Next, movement detection of the "finger-nose test" which is an example of the test performed in order to evaluate extent of the condition of disease of the hemiplegia patient by cerebral infarction was performed using the acceleration sensor and angular-velocity sensor with which the wrist was equipped. This is given by the subject by carrying out actuation which repeats a finger according to a metronome signal and it has in its nose. Drawing 7 is the graph which shows the measurement result of movement of the right hand in a finger-nose test, and a left hand by the detection wave as it is, an axis of abscissa is time amount (second), and an axis of ordinate is a detection value. As for a healthy person A, (c), and (d), (a) and (b) show a left upper extremity paralysis patient's case, as for a healthy person B, (e), and (f). Although a rhythm that acceleration and the angular velocity of any actuation of a near hand are smooth and fixed is accepted by two healthy persons for seeing these drawings In a hemiplegia patient, Il Tempo of operation is late, the wave is also confused, since it is especially remarkable in the case of the upper extremity by the side of paralysis, critical [of a symptom], improvement extent in comparison with the past data, etc. can judge easily, and it turns out that the body side equipment of a wrist mold is very effective.

[0032] Next, the experiment which identifies some kinds of walks by the movement sensor with which the wrist was equipped correctly using the measurement result of the acceleration and angular velocity of each direction was conducted. An axis of coordinates is as having been shown in drawing 5 , and the normal axis of the body in which the X-axis stood straight, and a Y-axis are an antero-posterior axis and a lateral axis with the level Z-axis. a test subject -- 14 man and woman in his 20-40's, and the class of movement -- usually -- a walk -- he already walked, and it is five sorts of a jogging, transit, and an arm restricted walk (folding its arms, pocket ON **, private secretary), and data extraction was performed by putting together 20 steps or 50 steps. A detection wave carries out data processing rather than remains as it is, and is processed. When one detects the peak (each peak value of the vibration-voltage waveform outputted from a measuring circuit according to a walk) of vibration, others have taken those logarithms further

by the case where distribution (average of the square of the difference of each data and the average) of the value of each point is calculated by having carried out multi-point sampling (the wave electrical potential difference under walk of 20 - 50 steps being sampled by 50Hz) of the wave. A result is divided into drawing 8 - drawing 10 , and is shown. It is drawing where drawing 8 (a) used the variance comrade of an acceleration wave of the X-axis and a Y-axis, and (b) used the peak value comrade of an acceleration wave of the X-axis and a Y-axis. Drawing 9 (a) takes X-axis acceleration and Z axial-angle rate, (b) takes Y-axis acceleration and Z axial-angle rate, and all are drawings using the peak value of a detection wave. It is drawing where, as for drawing 10 (a), both Y-axis acceleration and Z axial-angle rate used X-axis acceleration and Z axial-angle rate, and (b) used the variance comrade.

[0033] In drawing 8 (b) which combined the peak value comrade with seeing each drawing first and drawing 9 (a), and (b), it solidifies in the point of measurement which shows various kinds of movements mutually, and since there are some which are moreover considerably complex, there is a possibility that discernment of movement may not be ensured. Both drawings of drawing 1010 which combined acceleration and angular velocity in the example which combined the variance comrade of a detection wave to it although the separability of movement was bad in drawing 8 (a) which is an acceleration comrade have comparatively good separability. The direction of the (a) Fig. is considered that epicritic is a little good. [which used the vertical direction acceleration Gx and vertical - order side internal-version angular-velocity omegaz especially]

[0034] When it is common to use the vertical direction acceleration Gx and vertical - order side internal-version angular-velocity omegaz as a direction of susceptibility of movement in body side equipment from the above result, it is the optimal on movement discernment, and it is shown that it is realizable with body side equipment with sufficient wearing nature like drawing 3 and a sufficient feeling of use using the thin movement sensor which this is suitable also for the judgment of rehabilitation like drawing 7 , and has the detection direction like drawing 4 .

[0035] The gestalt of operation of this invention of not being caught by some gestalten described above is natural. For example, the direction of the susceptibility of acceleration or angular velocity may also choose bearing which changes with purposes of using equipment. The data transmitted and received between body side equipment and an external device may be what kind of thing, as long as required movement information is transmitted. Moreover, body side equipment may be equipped with functions, such as a clock and a cellular phone, (a clock function can be used also for control of timing). Moreover, the stowed position of body side equipment can also not necessarily be made into the location of for example, not only a wrist but arm top arbitration. moreover, a movement measurement result -- always -- drawing 8 -- it may not restrict processing it as follows and displaying, but as shown in each drawing of drawing 7 , the detection wave of acceleration or angular velocity may be displayed as it is. Moreover, in quest of the average of an absolute value etc., there may be versatility besides the experiment having shown data processing of measured value. Moreover, other acceleration or angular velocity of a direction are also measured, it considers as an auxiliary data, and raising the precision of a diagnosis or movement evaluation is also considered.

[0036] Moreover, as an application of this equipment, it is not restricted to extraction and evaluation of movement data, for example, there is use as a communication tool. To a remote medical person in charge, a user can perform as a signal body actuation which fixed beforehand how many kinds of those demands and volitional transfer, such as "wanting you to come immediately", can analyze a movement detection wave by the external device side, and can know, the signal actuation, i.e., intention.

[0037]

[Effect of the Invention] Since the acceleration of one direction and the angular rate of rotation of one direction are detected, a predetermined operation is added to them and movement is judged or evaluated, it is a simple configuration and body side equipment is miniaturized by the sensor and measuring circuit of (1) minimum, and the body actuation sensing equipment of this invention can also give allowances to the power source, and has effectiveness with the fundamental communication tool which is easy to deal with it.

[0038] By adding the requirements for a configuration of claims 2-7 to the configuration of claim 1, the following effectiveness can be added further, respectively.
(2) Since the direct reading of a judgment result of operation or the evaluation result can be carried out with body side equipment, it is effective in the ability of a user to control oneself health easily.
[0039] (3) Since a judgment result of operation and an evaluation result are displayed on an external device side by the data transmission from body side equipment, by it, the condition of two or more users (patient) by the medical institution side can be observed and managed. Moreover, it is effective in the ability to receive the message from a user and perform corresponding treatment.
[0040] (4) By specifying the detection direction about the body of the rectilinear motion of body side equipment, and rotation, it is effective in the need and sufficient information according to the purpose being acquired with the small detection important point prime factor. Moreover, since the both sides of an important walk, transit movement, and movement of an upper extremity are especially detectable, presumption of consumption energy and evaluation of rehabilitation are attained, for example.
[0041] (5) the largest field of body side equipment, the largest field of a thin movement sensor, and detection -- since surface of revolution was made almost parallel, there is effectiveness in which a feeling of a wearing burden has realized little body side equipment with the thin shape.
[0042] (6) Since the acceleration sensor was furthermore united with the angular-velocity sensor and it piled up with the display, there is effectiveness in which it was miniaturized further and legible body side equipment has also realized the display.
[0043] (7) By asking for distribution of an acceleration output or an angular-velocity output, it is effective in distinction of the class of movement becoming clearer.
[0044] (8) By furthermore taking the logarithm of a movement measurement value, it is effective in distinction of the class of movement becoming still clearer.

TECHNICAL FIELD

[Field of the Invention] This invention detects movement which the body performed and relates to the body actuation sensing equipment which can provide a watcher with the information.

PRIOR ART

[Description of the Prior Art] Many [the proposal of invention which attaches in a user's body, detects movement of the body by the sensor, judges a user's movement situation by the data, and is used for the purposes, such as health care,] For example, telephone transmission is carried out, the momentum which carried out automatic meter reading to the inputted personal data is analyzed to an external center computer, and the personal digital assistant which has the accelerometer which the user put on in the technique indicated by (1) JP,10-295651,A (waist etc.) carries out a medical checkup to it, and receives and displays the result.
[0003] (2) In the technique indicated by JP,2000-41953,A, process the primary body motion which the body motion sensor of an action data collector (user body side) detected, and the action data output equipment (external personal computer side) which received it outputs the data which carried out secondary elaboration using individual humanity news. Individual humanity news input by the side of a living body information gathering device and are recording of a lot of secondary elaboration information are made unnecessary, and reduction of operability or memory space is aimed at.
(3) In JP,2000-41952,A, in order to reduce the memory space of an action information detection device, from the output of a sensor and a body motion detector, calculate biological information, such as the number of steps, a walk pace, a class of action, exercise intensity, and a consumption calorie, using Interior MPU, and transmit a count result to storage, a display, or the exterior for every minute.

[0004] (4) It seems that in addition, an acceleration sensor is made to build in a pedometer (pedmeter (trademark)), the wrist watch of a multifunctional mold, etc., and there were also the product and reference which measure the number of steps and exercise intensity and told health management information, such as a consumption calorie by movement.
(5) In order to perform the monitoring of actuation of the patient who produced the failure in action, or an urgent automatic announcement for the purpose on medical supervision furthermore, in addition to an acceleration sensor, angular-rate-of-rotation sensors, such as an oscillating gyroscope, are added, and a report [in / in research and an experiment of specification aiming at detection of movement being made / a related society] etc. sees.
(6) On the other hand, when the movement sensor technique was seen, acceleration and angular velocity were conventionally measured by the separate sensor. By the angular-velocity sensor, the oscillating gyroscope which used the free free bar and the tuning fork of 2 pieces as an oscillating object which detects Coriolis force is being used especially.

EFFECT OF THE INVENTION

[Effect of the Invention] Since the acceleration of one direction and the angular rate of rotation of one direction are detected, a predetermined operation is added to them and movement is judged or evaluated, it is a simple configuration and body side equipment is miniaturized by the sensor and measuring circuit of (1) minimum, and the body actuation sensing equipment of this invention can also give allowances to the power source, and has effectiveness with the fundamental communication tool which is easy to deal with it.
[0038] By adding the requirements for a configuration of claims 2-7 to the configuration of claim 1, the following effectiveness can be added further, respectively.
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[0039] (3) Since a judgment result of operation and an evaluation result are displayed on an external device side by the data transmission from body side equipment, by it, the condition of two or more users (patient) by the medical institution side can be observed and managed. Moreover, it is effective in the ability to receive the message from a user and perform corresponding treatment.
[0040] (4) By specifying the detection direction about the body of the rectilinear motion of body side equipment, and rotation, it is effective in the need and sufficient information according to the purpose being acquired with the small detection important point prime factor. Moreover, since the both sides of an important walk, transit movement, and movement of an upper extremity are especially detectable, presumption of consumption energy and evaluation of rehabilitation are attained, for example.
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[0044] (8) By furthermore taking the logarithm of a movement measurement value, it is effective in distinction of the class of movement becoming still clearer.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] It is still small fully for seeing the gestalt of each implementation of invention in the above-mentioned conventional example (1), (2), and (3), and

the burden of the user (the body is an inconvenient patient in many cases) by wearing is considered that it cannot say that few body side devices are proposed. Although there is an advance in respect of the miniaturization of a device in the conventional example (4), it is not the technique which the information which it is going to acquire in these conventional examples has stopped within the limits of a healthy person's health care, for example, can be immediately used also for the medical purposes, such as evaluation of a patient's rehabilitation.

[0006] Although the purpose of research of the above-mentioned conventional example (5) also have the point which be common in this invention in it be the improvement of the iatrotechnique, detection of the actuation relevant to it be target the specific disease as the concrete purpose (for example, movement which a burden require for a circulatory system disease and cardiac performance), and there be many parts which cannot apply actuation of paralytic [by cerebral infarction] to this invention which it be going to put into a visual field easily directly, either. It seems that moreover, there is no reference about the concrete optimal technique which actually equips a patient with a movement sensor not much.

[0007] Moreover, surface of revolution, the revolving shaft with which the angular-velocity sensor in the conventional technique mentioned as the conventional example (6) can detect angular velocity, i.e., detect, on the longitudinal shaft of the tuning fork of 2 pieces or a cylindrical oscillating object, is perpendicular to a longitudinal shaft. This increases the thickness of body side equipment inevitably, when parallel to the main front faces of the equipment which equips the body with detectable surface of revolution. Moreover, body side equipment will be carried out to an acceleration sensor and an angular-velocity sensor being another objects on a large scale. In order to mitigate the feeling of a burden of wearing according to these situations, in the present condition, it is difficult a thin shape and to make it small. In addition, there are also many examples as which the sensor of other gestalten was proposed.

[0008] The purpose of this invention is offering the high body actuation sensing equipment of the practicality with which detects actuation of a user's body, can distinguish it being predetermined actuation, and can display the information, and he or an observer can be provided. Moreover, it is offering the body actuation sensing equipment which enabled measurement of a walk, and evaluation of rehabilitation at least.

MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the body actuation sensing equipment of this invention is equipped with the following description.

(1) The movement sensor which can measure the acceleration of one direction, and the surrounding angular rate of rotation of one shaft, The body side equipment with which the predetermined part of the body is equipped including a measuring circuit means by which predetermined carries out period measurement of the acceleration of said one direction, and the surrounding angular rate of rotation of one shaft, by this movement sensor, An arithmetic circuit means to perform a predetermined operation to the acceleration output and angular-velocity output of this measuring circuit means, respectively, Have a judgment circuit means to judge the class and reinforcement of body movement in said predetermined period with the combination of the acceleration output and angular-velocity output to which said predetermined operation was performed, and said display means to display the class and the reinforcement, or its evaluation result of judged body movement.

[0010] The body actuation sensing equipment of this invention may be further equipped with at least one of the following descriptions.

(2) Be built in the body side equipment with which the predetermined part of the body is equipped with all of said movement sensor, said measuring circuit means, said arithmetic circuit means, said judgment circuit means, and said display means.

[0011] (3) Said movement sensor, said measuring circuit means, and said arithmetic circuit means, It is built in the body side equipment with which the predetermined part of the body is equipped with said movement sensor and said measuring circuit means at least among said judgment circuit means and said display means. Other means are built in the external device

with which said body is not equipped, and said body side equipment should have been equipped with the transmitting means of middle data, and said external device should be equipped with the receiving means of said middle data.
[0012] (4) The angular velocity of one direction where the body is the acceleration of the vertical direction mostly, and said movement sensor detects the acceleration of one direction which said movement sensor detects should be the angular velocity to rotation within the flat surface of the body which contains the direction of a vertical, and a cross direction mostly.
[0013] (5) Said body side equipment is a device with which an arm is equipped, in the interior, the angular-velocity sensor section of said movement sensor is contained by the container of a core box with thin thickness, and is arranged almost in parallel with the largest field of said body side equipment, and the detection hand of cut of said angular-velocity sensor section should be a direction almost parallel to the largest front face of the container of said core box.
[0014] (6) Said body side equipment has a display on the main front faces, and the acceleration-sensor section and the angular-velocity sensor section of structure which were unified are contained by the container of the core box of said movement sensor, and the container of said movement sensor is arranged in said body side equipment almost in parallel with said display, and the acceleration detection direction of said movement sensor should be a direction almost parallel to the largest front face of the container of said core box.
[0015] (7) Said predetermined operation should be asking for one [at least] distribution of said acceleration output and said angular-velocity output.
[0016] (8) Said predetermined operation should be asking for one [at least] distribution of said acceleration output and said angular-velocity output, and taking the logarithm further.
[0017]
[Embodiment of the Invention] Drawing 1 is the block diagram of the gestalt of operation of the 1st of the body actuation sensing equipment of this invention. This equipment consists of the body side equipment 1 which a user attaches in the predetermined part of the body, and the external device 2 installed in a medical center-location. The internal configuration of body side equipment 1 The acceleration to the specific direction The angular velocity of rotation parallel to the acceleration sensor 11 to detect and a specific field Excite respectively the angular-velocity sensor 12 to detect and the sensor which is these mechanical oscillation object, extract the detecting signals P11 and P12 of acceleration and angular velocity again (a driving signal is P130 and P140), and detection, magnification, etc. are processed. The acceleration measuring circuit 13 and the angular-velocity measuring circuit 14 which output the electrical potential difference which is proportional to a detection value, respectively are included.
[0018] As for the acceleration output P13 and the angular-velocity output P14 within a predetermined period (or the user itself decides, beforehand, a user and a medical staff arrange, and it decides, or it is considered variously that equipment determines by the self clock etc.), a predetermined operation is performed by the acceleration arithmetic circuit 15 and the angular-velocity arithmetic circuit 16, respectively. A predetermined operation is processing it into the wave of signals P13 and P14, and changing a signal. For example, equalize by performing rectification and smoothing which extracts the peak value of an input wave. It means searching for those logarithms or performing other mathematical processings, furthermore it samples finely the signal of the predetermined period which calculates the variance of wave-like peak value which appears at a predetermined period and takes out the variance, asking for the vibrating wave-like period, etc. The movement data which are those outputs are the acceleration operation output P15 and the angular-velocity operation output P16. Both this output is transmitted [as opposed to / as an electric-wave output P22 / an external device 2 / both] by the communication circuit 22. Both communication circuits 22 and 23 cooperate, and transmission and reception of data are performed in both directions, checking mutual actuation. Moreover, a control circuit 24 acts on each circuit in body side equipment 1, generates control signals P241, P242, P243, P244, and P245, and has the role which adjusts the cooperation actuation between the timing of each circuit of operation, or each circuit.
[0019] The configuration and actuation of an external device 2 are as follows. The communication circuit 23 which received the movement data contained in the electric-wave

signal P22 restores to it, and changes it into the internal signal P23. In response to the internal signal P23, beforehand, the movement judging circuit 17 compares two kinds of information included in it, an acceleration operation output and an angular-velocity operation output, with each numerical range for which it asked experimentally about that movement, and judges how many kinds of the classes and reinforcement of movement which the user performed within a certain period. Or the information on evaluations (for example, progress situation of rehabilitation etc.) over movement judged further is also added.

[0020] The judgment result signal P17 including those information is sent to a display 18 (a required circuit is included), it is displayed with the individual humanity news of the user by whom the contents (the class of movement, reinforcement, its evaluation) etc. were registered beforehand, is recorded with a recording device 21, and enables a diagnosis of observers, such as a medical person in charge, while storage 19 memorizes. Moreover, a regenerative circuit 20 is reproduced at any time as a regenerative signal P20 if needed, and the storage signal P19 including the memorized contents is displayed with a display 18. A control circuit 26 acts on each circuit in an external device 2, receives an input signal P231, generates control signals P251, P252, P253, P254, P255, and P256, and has the role which adjusts the cooperation actuation between the timing of each circuit of operation, or each circuit.

[0021] Drawing 2 is the block diagram of the gestalt of operation of the 2nd of the body actuation sensing equipment of this invention. In this example, in body side equipment 1, it has each required circuit and required display 18 which were already explained (a communication circuit becomes unnecessary), the situation of movement and the information on the evaluation are displayed, and there is an advantage to which the user (wearer) itself can check it. It is possible to make it reproduce later on, to make a third person etc. check or to also make information memorized, of course record on an external instrument by the regenerative circuit 20. A control circuit 26 acts on each circuit in body side equipment 1, generates control signals P261, P262, P263, P264, and P265, and adjusts the cooperation actuation between the timing of each circuit of operation, or each circuit.

[0022] Drawing 3 shows an example of the body side equipment in the gestalt of operation of this invention, (a) is a part plan and (b) is the A-A sectional view. This body side equipment 3 is carrying out the wrist watch mold mostly, is equipped with the band 36 for arm volumes, and can equip a wrist with it. The movement sensor 31, the indicating equipment 32, the communication circuit module 33, the cell 34 used as a power source, and the actuation switch 35 were shown as main components. Body side equipment 3 must be a thin shape and small so that wearing may not become a user's burden. When a display 32 thinks conspicuousness as important, it will be arranged on the largest front face of the body side equipment 3 equivalent to the screen of a wrist watch. According to the same field, the movement sensor 31 is also arranged in parallel with a display 32. Since a display 32 can use thin things, such as a liquid crystal display panel, the movement sensor 31 must also be dedicated to the sufficiently thin package.

[0023] The reason for arranging the movement sensor 31 in parallel with a display 32 is as follows. The optimal movement detection direction turns to the rotation within the direction of X shown in the rectilinear motion, i.e., the (a) Fig., of the vertical (vertical) direction of the body about acceleration, and the flat surface which includes the both sides of the vertical direction of the body, and a cross direction about the angular rate of rotation (the direction of omega of this drawing), i.e., the longitudinal direction of the body, from an experimental result which is described later, and is rotation of the circumference of a level revolving shaft (parallel to the illustration Z-axis). body side equipment 3 -- a wrist watch -- like -- the screen -- the shell side of a wrist, or a palm, when supposing that it equipped so that it might become a side (this is the most natural and desirable), uprighting the upper part of the body, bending an elbow automatically, lengthening it and carrying out it Since the surface of revolution becomes parallel to the screen 32 of body side equipment 3, i.e., a display, if there is a thin angular-velocity sensor with a rotation detection side parallel to the largest field, it is desirable to arrange the movement sensor 31 which contains it inside in parallel with a display 32.

[0024] Drawing 4 is the top view showing the internal structure of an example of the movement sensor in the gestalt of operation of this invention. The structure of this movement sensor fills all

of the above configurations, arrangement, and the demand about the detection direction. 40 is a container airtight (preferably vacuum) by the thin core box, and it has removed the lid (head-lining part of a container) in order to show a internal structure. 41 is the hermetic terminal pin of a large number which penetrate the pars basilaris ossis occipitalis of a container. Although each pin is connected by each of the electrode layer group on the movement sensor oscillating object 50, and the technique of wirebonding, the electrode layer and the bonding wire have omitted illustration. The movement sensor oscillating object 50 is fabricated from the plate of the piezoelectric ingredient of one sheet, and the acceleration-sensor section and the angular-velocity sensor section are unified. the movement sensor oscillating object 50 -- the fixed part A52 (slash section) of the rear face of the total base 51, and a facet -- on the plinth by the side of a container 40 (not shown), the rear face of the fixed part B64 (slash section) of a product pastes up, and is supported.

[0025] The angular-velocity sensor section is the part which carried out the so-called tripod tuning fork type of configuration, and consists of the parallel outside foot A53, the outside foot B55, the inside foot C54 and the tuning fork base 56, and the supporting point 57 respectively. It is excited with the fixed amplitude by the excitation circuit (oscillator circuit) included in an angular-velocity measuring circuit (for example, 13 of drawing 1) so that the outside foot A53 and the outside foot B55 may be cantilever-like [each] like the usual 2-piece tuning fork and symmetrical vibration may be performed about a symmetry axis (not shown). Although the inside foot C54 is not excited, it has a surface electrode for detecting the bending. 58A, 58B, and 58C which attached and showed different hatching from a fixed part are an additional mass, respectively, and in order to lower a resonant frequency and to make it equal mutually, they consist of the thick deposit of the metal given to the foot point etc. (the resonant frequency of the inside foot C54 may give a difference as suitably as the resonant frequency of both ****).

[0026] If the movement sensor 50 rotates with angular velocity omega now around a revolving shaft parallel to the Z-axis perpendicular to the direction of illustration, i.e., space, the Coriolis force proportional to angular velocity omega will act on the oscillating foot of both outsides. The direction is a longitudinal direction of a foot, and if the force of the foot tip sense acts on the foot A53 outside a certain moment, the force of going to the base of a foot will act on the outside foot B55. The direction of the force changes in sine synchronizing with vibration of a foot, and is reversed periodically. Since it is separated from two force of both **** in parallel, a couple is constituted, the tuning fork base 56 is shaken, and a minute rotational vibration is caused in the surroundings of the supporting point 57. Sensing vibration of the tuning fork base 56 resulting from the moment by this Coriolis force, the inside foot C54 vibrates with the amplitude proportional to Coriolis force. The oscillating electrical potential difference extracted with the detection electrode prepared in the inside foot C54 is the detecting signal (R> 1 drawing 1 P11) of angular velocity.

[0027] The rod A61 whose acceleration-sensor sections of the movement sensor 50 are one pair of vibrating parallel spring sections, a rod B62, the load mass 60 (it consists of a part of mass of the material plate of a large area, and mass of the thick plating material given to the front face), It consists of two support springs 63 (member for allowing the minute variation rate of an illustration Z direction, supporting the load mass 60), and a fixed part B (part for carrying out support immobilization so that the load mass 60 may not displace greatly especially in the direction of X). The rod A61 which is both-ends immobilization respectively, and a rod B62 are excited by the oscillator circuit (for example, contained in the angular-velocity measuring circuit 14 of drawing 1) by the oscillating style which makes a symmetrical segment about the symmetry axis of the movement sensor 50.

[0028] Although the oscillation frequency is usually fixed, if the acceleration of the direction of illustration X acts on the load mass 60, the load mass 60 will compress or pull a rod A61 and a rod B62 to the longitudinal direction by the force proportional to the magnitude, and an oscillation frequency will fluctuate with the direction and magnitude of the force, and it will change. Then, the reference frequency and the above-mentioned oscillation frequency which were prepared separately are compared, and if the direction and amount of change of an oscillation frequency are got to know, it can ask for the acceleration of X shaft orientations.

Especially the source of reference frequency is not prepared, but the oscillation frequency of the outside feet A53 and B55 which are the oscillating objects for angular-velocity sensors can be used for instead of.

[0029] Next, many experiments which search for the gestalt of the optimal operation of this invention and which went to accumulate are explained using drawing 5 - drawing 10 . Drawing 5 is the explanatory view of the experiment situation of the oscillating response in body actuation sensing first. The body 4 which is a test subject was uprighted, one leg was put on standing ways 5, and other feet were put on the base of the vibration exciter 6 which vibrates in the direction of a vertical. In addition, the axis of coordinates of X, Y, and Z was set up like illustration on the basis of the body 4. The black dot given to the body 4 shows the part equipped with an acceleration sensor. And the response of the sensor with which at least each part to the excitation of the direction of X (the direction of a vertical) was equipped first was calculated. Excitation carried out the sweep of the 5-1000Hz with the fixed acceleration of 4.9m[/s] *s by the sine wave. In addition, the acceleration of the direction of X is also indispensable data, in order to ask for the consumption calorie in ordinary movement of a walk etc.

[0030] Drawing 6 is the graph which shows the experimental result of an oscillating response of the Z direction of the acceleration sensor with which at least each part of the body when exciting sole of one of the two on the above-mentioned experiment conditions was equipped, and the axis of abscissa showed an excitation frequency and the acceleration with which the axis of ordinate was detected with logarithmic scale, respectively. (a) is the case where the top of the head and (b) equip with a chest pocket and (c) the wrist at which a waist belt and (d) extended the ankle and (e) extended the elbow, and the wrist which (f) bent the elbow and was leveled, respectively. (c) When a waist belt, the (d) ankle, and the (e) elbow are lengthened, each **** of a wrist which bent the (f) elbow shows both at the time of attaching a sensor in a symmetrical part about the medial axis (field which divides right and left) of the case where it took and sticks to a bodily excitation side, and the body on the same Fig., and has made the comparison easy. The difference of a wave of the response by the side of excitation and the symmetry is [that there is almost nothing] the most gently-sloping in the (e) Fig. over the perimeter wave number range for seeing these data. Moreover, sole vibration of about 20Hz or more has low transmissibility, and the detection which could not be easily influenced of the hardness of footwear or the ground and was stabilized in detection of a walk or transit can be expected. It turns out that it is most excellent in these reasons to equip a wrist with a sensor generally if measurement of a special body region is not the purpose.

[0031] Next, movement detection of the "finger-nose test" which is an example of the test performed in order to evaluate extent of the condition of disease of the hemiplegia patient by cerebral infarction was performed using the acceleration sensor and angular-velocity sensor with which the wrist was equipped. This is given by the subject by carrying out actuation which repeats a finger according to a metronome signal and it has in its nose. Drawing 7 is the graph which shows the measurement result of movement of the right hand in a finger-nose test, and a left hand by the detection wave as it is, an axis of abscissa is time amount (second), and an axis of ordinate is a detection value. As for a healthy person A, (c), and (d), (a) and (b) show a left upper extremity paralysis patient's case, as for a healthy person B, (e), and (f). Although a rhythm that acceleration and the angular velocity of any actuation of a near hand are smooth and fixed is accepted by two healthy persons for seeing these drawings In a hemiplegia patient, Il Tempo of operation is late, the wave is also confused, since it is especially remarkable in the case of the upper extremity by the side of paralysis, critical [of a symptom], improvement extent in comparison with the past data, etc. can judge easily, and it turns out that the body side equipment of a wrist mold is very effective.

[0032] Next, the experiment which identifies some kinds of walks by the movement sensor with which the wrist was equipped correctly using the measurement result of the acceleration and angular velocity of each direction was conducted. An axis of coordinates is as having been shown in drawing 5 , and the normal axis of the body in which the X-axis stood straight, and a Y-axis are an antero-posterior axis and a lateral axis with the level Z-axis. a test subject -- 14 man and woman in his 20-40's, and the class of movement -- usually -- a walk -- he already walked, and it

is five sorts of a jogging, transit, and an arm restricted walk (folding its arms, pocket ON **, private secretary), and data extraction was performed by putting together 20 steps or 50 steps. A detection wave carries out data processing rather than remains as it is, and is processed. When one detects the peak (each peak value of the vibration-voltage waveform outputted from a measuring circuit according to a walk) of vibration, others have taken those logarithms further by the case where distribution (average of the square of the difference of each data and the average) of the value of each point is calculated by having carried out multi-point sampling (the wave electrical potential difference under walk of 20 - 50 steps being sampled by 50Hz) of the wave. A result is divided into drawing 8 - drawing 10 , and is shown. It is drawing where drawing 8 (a) used the variance comrade of an acceleration wave of the X-axis and a Y-axis, and (b) used the peak value comrade of an acceleration wave of the X-axis and a Y-axis. Drawing 9 (a) takes X-axis acceleration and Z axial-angle rate, (b) takes Y-axis acceleration and Z axial-angle rate, and all are drawings using the peak value of a detection wave. It is drawing where, as for drawing 10 (a), both Y-axis acceleration and Z axial-angle rate used X-axis acceleration and Z axial-angle rate, and (b) used the variance comrade.

[0033] In drawing 8 (b) which combined the peak value comrade with seeing each drawing first and drawing 9 (a), and (b), it solidifies in the point of measurement which shows various kinds of movements mutually, and since there are some which are moreover considerably complex, there is a possibility that discernment of movement may not be ensured. Both drawings of drawing 1010 which combined acceleration and angular velocity in the example which combined the variance comrade of a detection wave to it although the separability of movement was bad in drawing 8 (a) which is an acceleration comrade have comparatively good separability. The direction of the (a) Fig. is considered that epicritic is a little good. [which used the vertical direction acceleration Gx and vertical - order side internal-version angular-velocity omegaz especially]

[0034] When it is common to use the vertical direction acceleration Gx and vertical - order side internal-version angular-velocity omegaz as a direction of susceptibility of movement in body side equipment from the above result, it is the optimal on movement discernment, and it is shown that it is realizable with body side equipment with sufficient wearing nature like drawing 3 and a sufficient feeling of use using the thin movement sensor which this is suitable also for the judgment of rehabilitation like drawing 7 , and has the detection direction like drawing 4 .

[0035] The gestalt of operation of this invention of not being caught by some gestalten described above is natural. For example, the direction of the susceptibility of acceleration or angular velocity may also choose bearing which changes with purposes of using equipment. The data transmitted and received between body side equipment and an external device may be what kind of thing, as long as required movement information is transmitted. Moreover, body side equipment may be equipped with functions, such as a clock and a cellular phone, (a clock function can be used also for control of timing). Moreover, the stowed position of body side equipment can also not necessarily be made into the location of for example, not only a wrist but arm top arbitration. moreover, a movement measurement result -- always -- drawing 8 -- it may not restrict processing it as follows and displaying, but as shown in each drawing of drawing 7 , the detection wave of acceleration or angular velocity may be displayed as it is. Moreover, in quest of the average of an absolute value etc., there may be versatility besides the experiment having shown data processing of measured value. Moreover, other acceleration or angular velocity of a direction are also measured, it considers as an auxiliary data, and raising the precision of a diagnosis or movement evaluation is also considered.

[0036] Moreover, as an application of this equipment, it is not restricted to extraction and evaluation of movement data, for example, there is use as a communication tool. To a remote medical person in charge, a user can perform as a signal body actuation which fixed beforehand how many kinds of those demands and volitional transfer, such as "wanting you to come immediately", can analyze a movement detection wave by the external device side, and can know, the signal actuation, i.e., intention.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram of the gestalt of operation of the 1st of this invention.
[Drawing 2] It is the block diagram of the gestalt of operation of the 2nd of this invention.
[Drawing 3] An example of the body side equipment in the gestalt of operation of this invention is shown, (a) is a part plan and (b) is the A-A sectional view.
[Drawing 4] It is the top view showing the internal structure of the movement sensor in the gestalt of operation of this invention.
[Drawing 5] It is the explanatory view of the experiment situation of the oscillating response in body actuation sensing.
[Drawing 6] It is the graph which shows the experimental result of the oscillating response like each part of the body, and the top of the head and (b) of (a) are [a chest pocket and (c)] the cases of the wrist at which a waist belt and (d) extended **** and (e) extended the elbow, and the wrist to which (f) bent the elbow and leveled it.
[Drawing 7] In the graph which shows the measurement result of movement of the right hand in a finger-nose test, and a left hand, as for a healthy person A, (c), and (d), (a) and (b) show a left upper extremity paralysis patient's case, as for a healthy person B, (e), and (f).
[Drawing 8] It is the graph which shows the experimental result which performed various kinds of body movements, carried out data processing of the movement data of each direction of a wrist, and combined them, and is drawing where (a) used the variance comrade of an acceleration wave of the X-axis and a Y-axis, and (b) used the peak value comrade of an acceleration wave of the X-axis and a Y-axis.
[Drawing 9] It is the graph which shows the experimental result which carried out data processing of the movement data of each direction of a wrist, and combined them, and (a) takes X-axis acceleration and Z axial-angle rate, (b) takes [various kinds of body movements are performed,] Y-axis acceleration and Z axial-angle rate, and all are drawings using the peak value of a detection wave.
[Drawing 10] It is the graph which shows the experimental result which performed various kinds of body movements, carried out data processing of the movement data of each direction of a wrist, and combined them, and is drawing where, as for (a), both Y-axis acceleration and Z axial-angle rate used X-axis acceleration and Z axial-angle rate, and (b) used the variance comrade.
[Description of Notations]
1 Three Body side equipment
2 External Device
4 Body
5 Standing Ways
6 Vibration Exciter
11 Acceleration Sensor
12 Angular-Velocity Sensor
13 Acceleration Measuring Circuit
14 Angular-Velocity Measuring Circuit
15 Acceleration Arithmetic Circuit
16 Angular-Velocity Arithmetic Circuit
17 Movement Judging Circuit
18 Display
19 Storage
20 Regenerative Circuit
21 Recording Device
22 23 Communication circuit
24, 25, 26 Control circuit
31 Movement Sensor
32 Display
33 Communication Module
34 Cell

35 Actuation Switch
36 Arm Volume Band
40 Sensor Container
41 Hermetic Terminal Pin
50 Movement Sensor Oscillating Object
51 The Total Base
52 Fixed Part A
53 Outside Foot A
54 Inside Foot B
55 Outside Foot C
56 Tuning Fork Base
57 Supporting Point
58A, 58B, 58C Foot additional mass
60 Load Mass
61 Rod A
62 Rod B
63 Support Spring
64 Fixed Part B
G Acceleration
Z Axis of coordinates
omega Angular velocity